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Are self-reported symptoms of executive dysfunction associated with objective executive function performance following mild to moderate traumatic brain injury?

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Abstract

Background and objective—We examined the relationship between self-reported pre- and post-injury changes in executive dysfunction, apathy, disinhibition, and depression, and performance on neuropsychological tests of executive function, attention/processing speed, and memory in relation to mood levels and effort test performance in individuals in the early stages of recovery from mild to moderate traumatic brain injury (TBI).

Method—Participants were 71 noncombat military personnel who were in a semiacute stage of recovery (<3 months post injury) from mild to moderate TBI. Pre- and post-TBI behaviors were assessed with the Frontal Systems Behavior Scale (FrSBe; Grace & Malloy, 2001) and correlated with levels of depressive symptoms, effort test performance, and performance on objective measures of attention, executive function, and memory.

Results—Self-reported symptoms of executive dysfunction generally failed to predict performance on objective measures of executive function and memory, although they predicted poorer performance on measures of attention/processing speed. Instead, higher levels of depressive symptomatology best predicted poorer performance on measures of executive function and memory. However, the relationship between memory performance and TBI symptoms was no longer significant when effort performance was controlled.

Conclusions—Our findings suggest that, among individuals in early recovery from mild to moderate TBI, self-reported depressive symptoms, rather than patients' cognitive complaints, are associated with objective executive function. However, self-reported cognitive complaints may be associated with objectively measured inattention and slow processing speed.

Keywords

Traumatic brain injury; Neuropsychology; Cognition; Behavior; Depression

INTRODUCTION

Approximately 1.6 million Americans sustain a concussion or traumatic brain injury (TBI) each year (Rutland-Brown, Langlois, Thomas, & Xi, 2006). TBI is especially prevalent within the military population, with estimates of TBI occurring in 7,000 active duty Americans each year during peacetime (Defense and Veterans Brain Injury Center, 2007). In recent years, TBI has become one of the signature combat-related injuries associated with the wars in Iraq and Afghanistan, with estimates of TBI occurring in more than 20% of surviving combat casualties (Defense and Veterans Brain Injury Center, 2007; Warden, 2006).

Approximately 90% of brain injuries are mild to moderate in severity (Kraus & McArthur, 1996; Defense and Veterans Brain Injury Center, 2010); with the frontal region being the most common area of the brain affected (Levin, 1987). Individuals with mild to moderate TBI often report behavioral, emotional, and cognitive symptoms in the days or weeks following their injury (Warriner & Velikonja, 2006). Common cognitive complaints in this population include inattention, executive dysfunction, memory deficits, and slowed processing speed (Arciniegas, Held, & Wagner, 2002; Frencham, Fox, & Maybery, 2005). One of the most frequent emotional changes reported by TBI survivors is depression (Bay & Donders, 2008; Jorge et al., 2004), with point prevalence rates of approximately 30% at one month post injury (Bombardier et al., 2010). While most often described in the severe TBI population (Andersson & Bergedalen, 2002; Hanks, Temkin, Machamer, & Dikmen, 1999; Prigatano, 1992), there is evidence that some individuals with mild to moderate TBI also report behavioral changes, such as impulsivity, reduced frustration tolerance, lack of empathy, emotional lability, amotivation, aggression, apathy, and disinhibition (Drake, Gray, Yoder, Pramuka, & Llewellyn, 2000; Hanks et al., 1999), although these behavioral changes in the acute mild-moderate TBI population have not been well characterized.

It has been suggested that the constellation of cognitive and behavioral symptoms in TBI may be associated with frontal system dysfunction; however, there is debate as to whether subjective complaints in mild-moderate TBI are verified by objective measurement. Evidence from blast-injury combat veterans (Brenner et al., 2010) and individuals with moderate to severe TBI (Allen & Ruff, 1990; Lannoo et al., 1998) suggest that subjective complaints and objective measurement of these complaints are not well coupled. Rather, subjective cognitive complaints are more highly correlated with levels of depression or emotional distress (Binder et al., 1999; Sillanpaa et al., 1997). Similarly, while several studies have found greater neuropsychological impairment in nonlitigating mild to moderate TBI individuals with subjective complaints than in those without complaints (Bohnen, Jolles, & Twijnstra, 1992; Chamelian & Feinstein, 2006; Gass & Apple, 1997), when depression was taken into account, the majority of these group differences dissipated (Chamelian & Feinstein, 2006). In support of these findings, a recent study by Lange and colleagues (Lange, Iverson, & Rose, 2011) found that depressed individuals with mild TBI and depressed individuals without a history of TBI endorsed greater post-concussive symptoms than mild TBI individuals without depression. Moreover, several studies have suggested that individuals with mild TBI may adopt a “good old days” bias, in which they view themselves as healthier in the past (Iverson, Lange, Brooks, & Rennison, 2010) and, therefore, may endorse an inflated increase in postconcussive symptoms. The “good old days” bias appears to be more pronounced in individuals who demonstrate poor-effort test

performances, confirming that poor effort is associated with increases in subjective complaints in mild TBI (Iverson et al., 2010).

In contrast, some studies have shown that self-reported cognitive complaints may be associated with at least some aspects of cognition, such as memory, sustained attention, and executive function over and above the effects of depression (Bohnen, Jolles, Twijnstra, Mellink, & Wijnen, 1995; Chamelien & Feinstein, 2006). Several studies have also questioned the impact of depression on cognitive performances in mild TBI (Bohnen et al., 1995; Rapoport, McCullagh, Shammi, & Feinstein, 2005). Unfortunately, comparisons and interpretations of these results are limited by differences in the methodological definitions of self-reported cognitive complaints (e.g., general vs. specific complaints), the cognitive domains assessed, the specific neuropsychological tests administered, and characteristics of the patient population (e.g., whether or not in litigation). In particular, the relationship between subjective complaints of frontal behavioral symptoms to objective executive function performance while taking into account depressive symptoms and effort test performance has not been fully examined in prior studies. Understanding the nature of subjective complaints in a mild to moderate TBI population may be useful for both accurate diagnosis and designing intervention strategies.

The aim of our study was to clarify the relationship among self-reported behavioral and cognitive complaints and objectively measured cognition in mild to moderate TBI in a semiacute stage of recovery. We employed standard cognitive and depression measures in addition to a well-validated measure of maladaptive behavior associated with frontal system dysfunction (Frontal Systems Behavior Scale, FrSBe; Grace & Malloy, 2001). We also used two measures of effort, the Reliable Digit Span (RDS) of the Wechsler Adult Intelligence Scale–Third Edition (WAIS–III; Wechsler, 1997a) and the Forced Choice Recognition Addendum of the California Verbal Learning Test–Second Edition (CVLT–II; Delis, Kramer, Kaplan, & Ober, 2000), to examine the relationships among subjective symptoms, objective cognitive performance, mood, and effort. We predicted that (a) self-reported symptoms of executive dysfunction would be retrospectively rated as having worsened from pre- to post-injury; (b) the subjective behavioral and cognitive postinjury complaints would be associated with greater levels of post-TBI depressive symptoms; (c) depression would best predict cognitive performance above and beyond subjective symptoms; and (d) TBI participants with suboptimal effort would endorse more subjective complaints than would those with optimal effort.

METHOD

Participants

Participants consisted of active duty personnel with a recent history of non-combat-related blunt-force TBI ($n = 71$). The majority of TBIs sustained (approximately 77%) were secondary to an accident (e.g., motor vehicle accident, fall), and the remainder (approximately 23%) were assault related (e.g., struck in the head with a closed fist or an object). As this was a retrospective study, information regarding loss of consciousness (LOC), Glasgow Coma Scale scores (GCS), and posttraumatic amnesia (PTA) was not fully available for each participant. All information was obtained by participant self-report. Forty-four (62%) of the participants were classified as having sustained a *mild TBI* defined by (a) an initial LOC of less than 30 minutes; (b) an initial GCS score between 13 and 15; and/or (c) PTA of less than 24 hours. Twenty-two (31%) participants were classified as having sustained a *moderate TBI* defined by (a) an initial LOC of greater than 30 minutes and less than 6 hours; (b) an initial GCS of 8–12; and/or (c) PTA greater than 24 hours, but less than 7 days. We classified the participants as moderate if they had at least one moderate-level symptom (i.e., LOC, GCS, PTA) or if they obtained positive scan findings (e.g., complicated

mild TBI; $n = 5$; Han et al., 2007; Han et al., 2009). Five (7%) participants could not be classified due to insufficient information, but still fell into the mild–moderate severity range based on the information that was available. These 5 participants were included in all of the analyses with the exception of the mild versus moderate TBI comparisons. All participants in this study were recruited from the Defense and Veterans Brain Injury Center (DVBIC), and each participant consented to the study using standard informed consent procedures approved by the Naval Medical Center San Diego and the Department of Veterans Affairs. The DVBIC in San Diego received patients from two primary sources: the Balboa Naval Medical Center San Diego and the Marine Corps Base Camp Pendleton. Exclusion criteria included (a) a history of previous severe head injuries; (b) past or current substance or alcohol abuse according to the *Diagnostic and Statistical Manual of Mental Disorders—Fourth Edition (DSM–IV)*; American Psychiatric Association, 1994) criteria; (c) a history of metabolic or other medical diseases known to affect the central nervous system (CNS); or (d) a history of Axis I psychiatric disorders according to the *DSM–IV*. Test data were collected for research purposes only.

Materials and procedure

Approximately three to nine weeks after the head injury (mean = 38.3 days, $SD = 11.8$ days; range = 17–63 days), participants were administered the following behavioral, neuropsychological, and emotional/mood measures:

Behavioral measure—The FrSBe is a brief behavior rating scale with demonstrated validity for the assessment of behavioral disturbances associated with damage to the frontal-subcortical brain circuitry (Grace & Malloy, 2001) and behavior symptoms associated with TBI (Reid-Armdt, Nehl, & Hinkebein, 2007). The FrSBe contains 46 questions that are self-rated on a Likert scale from 1 (*almost never*) to 5 (*almost always*). Each question is rated based on how the participant believes they were functioning (a) *before* the injury; and (b) at the present time, *after* the injury. The FrSBe yields four scores for each time point (i.e., *before* and *after* injury): a total score and three subscale scores (“Apathy,” “Disinhibition,” and “Executive Dysfunction”). All FrSBe scores were converted into T-scores corrected for age, education, and gender based on the administration manual (Grace & Malloy, 2001). T-scores below 60 indicate normal behavior, T-scores of 60 to 64 indicate *borderline* significance, and T-scores of 65 or above are considered *clinically significant*. Elevations on the Apathy subscale indicate problems with initiation, psychomotor retardation, spontaneity, drive, persistence, loss of energy and interest, lack of concern about self-care, and/or blunted affective expression. Elevations on the Disinhibition subscale (which we call Behavioral Disinhibition for the purposes of this study) are indicative of difficulties with inhibitory control, impulsivity, hyperactivity, social inappropriateness or lack of conformity to social convention, excessive emotional expression, emotional lability, explosiveness, and/or irritability. Finally, elevations on the Executive Dysfunction subscale (which we call Subjective Executive Dysfunction for the purposes of this study) signify self-reported problems with sustained attention, working memory, organization, planning, future orientation, sequencing, problem solving, insight, mental flexibility, self-monitoring of ongoing behavior, and/or ability to benefit from feedback or modify behavior following errors (Grace & Malloy, 2001).

Cognitive measures—The neuropsychological measures used in this study included the Digit Span and Digit Symbol subtests from the WAIS–III (Wechsler, 1997a); Visual Reproduction from the Wechsler Memory Scale–Third Edition (WMS–III; Wechsler, 1997b), the CVLT–II (Delis et al., 2000), Matrix Reasoning from the Wechsler Abbreviated Scale of Intelligence (WASI; Wechsler, 1999), and the Trail Making Test from the Delis–Kaplan Executive Function System (D-KEFS; Delis, Kaplan, & Kramer, 2001). The

aforementioned tests were selected for this study as they represent measures of attention, executive functioning, and memory domains that have been found to be sensitive to TBI (Arciniegas et al., 2002; Frencham et al., 2005). For the purposes of increasing statistical power and based on the methods employed by similar studies (Reid-Arndt et al., 2007), composite scores were created for three cognitive domains previously shown to be sensitive to TBI (Frencham et al., 2005). These composite scores were composed of the average of demographically corrected scaled scores across tests hypothesized to measure that domain. The *attention/processing speed* composite score included the WAIS–III Digit Span total and the WAIS–III Digit Symbol total scores. The *memory* composite score included the WMS–III Visual Reproduction II, the WMS–III Visual Reproduction Recognition total, the CVLT–II Long Delay Free Recall, and the CVLT–II Recognition scores. The *executive function* composite score included the WASI Matrix Reasoning and the D-KEFS Trail Making Test Number–Letter Switching condition scores. A principal component analysis (PCA) with orthogonal (varimax) rotation was performed that verified that the original test scores loaded onto independent components representing the aforementioned domains (Table 1).

Emotional measure—The Beck Depression Inventory (BDI) was used as a measure of depressive symptomatology (Beck, Ward, Mendelson, Mock, & Erbaugh, 1961).

Effort measures—The WAIS–III RDS (Wechsler, 1997a) and the CVLT–II Forced Choice Recognition addendum (Delis et al., 2000) were used as measures of effort. A cutoff score of 7 or less was used for the RDS (Mathias, Greve, Bianchini, Houston, & Crouch, 2002), and a cutoff score of 14 or less was used for the CVLT–II Forced Choice Recognition addendum (Moore & Donders, 2004) to represent suboptimal effort performance.

Statistical analysis

Two-tailed, paired-sample *t* tests were used to compare FrSBe retrospective preinjury and current postinjury scores. Independent-samples *t* tests were used to examine behavioral, cognitive, and emotional differences between mild and moderate TBI subgroups. Pearson product correlations were used to examine the relationship among behavior, cognitive, mood, and severity variables. Stepwise multiple regression analyses were performed using the cognitive composites as the dependent variables and the BDI, FrSBe subscale, and TBI severity scores as independent variables. Finally, independent-samples *t* tests were used to evaluate symptom and performance differences between suboptimal and optimal effort groups. In order to evaluate the role of effort on the relationships among objective and subjective symptoms, the aforementioned correlational analyses and stepwise regressions were conducted, excluding individuals with suboptimal effort.

RESULTS

Demographic information, including the participants' mean age, sex, education level, military rank, and days from injury are presented in Table 2. Neuropsychological test scores are presented in Table 3. Correlations between demographic variables and measures of subjective behavioral change from pre- to post-injury (i.e., FrSBe *after* score minus FrSBe *before* score) were not statistically significant (all *ps* > .10).

Changes in behavioral symptoms from pre- to post-injury

On average, the TBI participants retrospectively self-rated all behaviors associated with Apathy, Behavioral Disinhibition, and Subjective Executive Dysfunction prior to their TBI to be within normal limits (Figure 1). After injury, there was a significant increase in all of self-reported maladaptive behaviors from pre- to post-TBI (mean *T*-score change for Apathy = 19.1, *SD* = 18.0; mean *T*-score change for Behavioral Disinhibition = 5.2, *SD* = 8.8; mean

T-score change for Subjective Executive Dysfunction = 14.2, $SD = 17.2$; all $ps < .001$). As depicted in Figure 1, participants reported *borderline* levels of Subjective Executive Dysfunction ($M = 60.9$; $SD = 21.3$) after injury. Although self-reported Apathy and Behavioral Disinhibition also significantly increased from pre- to post-TBI levels, scores remained within normal limits (i.e., below a T-score of 60; $M = 59.5$, $SD = 18.6$; $M = 52.4$, $SD = 13.0$, respectively) post-injury.

Mild versus moderate subgroup comparisons

Independent-samples t tests revealed no significant differences in age, education, and days post injury in mild versus moderate TBI samples (all $ps > .05$). The samples did not differ on any FrSBe subscales prior to injury (all $ps > .56$), although the moderate TBI sample self-reported greater changes in subjective executive dysfunction and apathy post injury. Compared to the mild TBI sample, the moderate TBI sample endorsed a greater severity of depressive symptoms and evidenced poorer memory and attention/processing speed on neuropsychological composite scores. The groups did not differ on the objective executive function composite score (see Table 4 for details).

Correlations among behavioral symptoms, cognition, mood, and TBI severity

Correlations between FrSBe pre-TBI (*before*) subscale scores were not significantly associated with depression, objective cognitive, or TBI severity scores (all $ps > .07$). As depicted in Table 5, the three FrSBe post-TBI (*after*) subscale scores were significantly associated with the BDI (r -values ranged from .41 to .69, $ps < .002$), Attention/Processing Speed (r -values ranged from $-.26$ to $-.44$, all $ps < .03$), Executive Function (r -values ranged from $-.23$ to $-.34$, $ps < .03$), and Memory (r -values ranged from $-.31$ to $-.37$, $ps < .01$) composite scores, with the exception of a nonsignificant association between the FrSBe Behavioral Disinhibition postinjury subscale score and the Memory composite score ($r = -.14$, $p = .26$). The association between the FrSBe Behavioral Disinhibition postinjury subscale score and the Executive Function composite score just failed to reach statistical significance ($r = -.23$, $p = .055$). TBI severity was associated with the FrSBe post-TBI Apathy score ($r = -.23$, $p = .04$).

Increases in self-reported dysexecutive behaviors (pre-to post-TBI “change” scores) were significantly correlated with greater levels of depressive symptoms (r -values ranged from .33 to .65, all $ps < .01$) and poorer cognitive performance (r -values ranged from $-.28$ to $-.45$, all $ps < .02$), with the exception of a nonsignificant relationship between self-reported Behavioral Disinhibition and objectively measured Attention/Processing Speed ($p = .17$). Changes in self-reported behaviors were not significantly associated with level of TBI severity (all $ps > .13$).

Behavioral and mood predictors of cognition

To determine which factors contributed most to objectively measured cognitive functioning, we conducted three stepwise multiple linear regression analyses, with the Executive Function, Memory, and Attention/Processing Speed composite scores serving as the dependent variables in separate regression analyses and the post-TBI (“after”) FrSBe subscale (“Apathy,” “Disinhibition,” and “Executive Dysfunction”), TBI severity (mild vs. moderate), and BDI scores serving as independent variables.

In the first regression analysis, with the objective Executive Function composite score serving as the dependent variable, depressive symptomatology was the only significant predictor ($R^2 = .14$), $F(1, 66) = 10.47$, $p = .002$. None of the FrSBe scores or TBI severity contributed to the model.

In the second analysis, with the Memory composite score serving as the dependent variable, again only depressive symptoms accounted for a significant proportion of variance ($R^2 = .17$), $F(1, 66) = 13.58$, $p < .001$. None of the FrSBe subscale scores or TBI severity accounted for any additional significant variance in the model.

In the third regression analysis, with the Attention/Processing Speed composite score serving as the dependent variable, the FrSBe Executive Dysfunction subscale score was the only significant predictor ($R^2 = .20$), $F(1, 66) = 16.65$; $p < .001$. The FrSBe Disinhibition, FrSBe Apathy, BDI, and TBI severity variables did not account for any additional significant variance.

Role of effort on behavioral symptoms and cognition

Fifteen individuals (21%) performed below expectations on one or both embedded measures of effort (CVLT-II Forced Choice or RDS). Eleven and 9 participants scored below the cutoff scores on the CVLT-II Forced Choice and RDS, respectively, and of those, 5 fell below the cutoff scores on both measures. In order to evaluate the effect of effort on symptom reporting and objective cognitive performance, the TBI participants were divided into two effort testing subgroups based on their performance on the CVLT Forced Choice or RDS: (a) passed both measures ($n = 56$) or (b) scored below the cutoff on at least one measure ($n = 15$). A Pearson chi-square test revealed a significant difference between mild (11.4%) and moderate (40.9%) TBI participants who scored below the cutoffs on at least one measure, $\chi^2(1, N = 66) = 7.7$, $p < .01$.

Independent-samples t tests revealed that those who scored below the cutoffs on at least one effort measure were found to have significantly higher depressive symptomatology, greater changes and postinjury complaints of executive dysfunction and apathy, and poorer objectively measured memory, executive function, and attention/processing speed than those who passed both effort measures (Table 6). The groups did not differ in their reporting of preinjury behaviors. We subsequently performed the same correlational analyses and stepwise regressions detailed above with the exclusion of these 15 individuals who demonstrated questionable or suboptimal effort. Correlational analyses revealed that associations between behavioral complaints and objective performance were reduced for most comparisons (Table 7). Similar to the analyses of the total sample, the BDI was the only significant predictor of objective executive functioning ($R^2 = .08$), $F(1, 53) = 4.22$; $p = .045$, and Attention/Processing Speed was best predicted by the FrSBe (subjective) Executive Dysfunction subscale ($R^2 = .14$), $F(1, 53) = 8.20$; $p = .006$. However, when the 15 suboptimal effort participants were excluded, the regression with memory serving as the criterion failed to reach statistical significance.

DISCUSSION

Consistent with previous reports (Drake et al., 2000; Hanks et al., 1999), our results revealed significant increases in pre- to post-injury levels of self-reported dysexecutive behaviors and cognitive complaints in non-combat military personnel in a semiacute stage of mild to moderate TBI recovery. While self-reported levels of apathy, behavioral disinhibition, and subjective executive dysfunction were rated to be within normal limits prior to sustaining a TBI, participants rated their levels of executive dysfunction to be *borderline* significant following their injury. Increases in apathy and subjective behavioral disinhibition were also endorsed after injury, yet remained subclinical in level of severity, with apathy just below the cutoff for borderline significance. As participants retrospectively rated their preinjury symptoms, and these symptoms could not be corroborated by external sources, it is unknown whether their reports represented actual symptom changes or whether their recollection was

subject to a “good old days” bias (Iverson et al., 2010; Lange, Iverson, & Rose, 2010), in which they underestimated the symptoms they were experiencing pre-injury.

Compared to mild TBI, the moderate TBI group self-reported greater changes in executive dysfunction and apathy, but they did not differ in their ratings of behavioral disinhibition. Mild TBI samples did not self-rate any of their behaviors (pre- or post-TBI) as clinically significant, whereas the moderate TBI group self-rated their postinjury levels of executive dysfunction and apathy as clinically significant. While it is tempting to conclude that endorsement of increases in behavioral symptoms are associated with greater TBI severity, it is important to note that a large number of our moderate TBI sample scored below the cutoffs on at least one effort test compared to our mild sample (41% vs. 11%, respectively). Moreover, TBI severity level failed to correlate with any of the objective or subjective symptoms. Since our classification was made based on self-report, it is plausible that the moderate sample may have misreported their peri-injury status (e.g., LOC, PTA). The confirmation of subjective retrospective reports is a problematic issue in studies of mild to moderate TBI and a topic in need of further research (Ruff, Iverson, Barth, Bush, & Broshek, 2009).

When considering our entire sample, our results are consistent with several prior studies that demonstrated a strong relationship between depressive symptomatology and objective cognitive performance (Chamelian & Feinstein, 2006; Rapoport et al., 2005). In contrast to some studies that suggest that some aspects of objective executive function or memory are associated with self-reported cognitive complaints above the effects of depression (Bohnen et al., 1995; Chamelian & Feinstein, 2006), we found that depressive symptoms were a better predictor of objective executive function and memory performance in a general mild-moderate acute-recovery TBI sample. These results are aligned with studies that have shown that a subgroup of depressed individuals experience impairments in executive function and memory (Burt, Zembar, & Niederehe, 1995; Massman, Delis, Butters, Dupont, & Gillin, 1992; Ottowitz, Dougherty, & Savage, 2002). As TBI severity level did not correlate with objective executive function or memory performance, our results suggest that depressive symptomatology, rather than neurologic damage secondary to TBI, may account for executive function and memory problems in mild to moderate TBI. As one third of individuals in acute recovery TBI have clinically significant depression, and post-concussive syndrome is often misdiagnosed in depressed individuals (Bombardier et al., 2010; Iverson, 2006), these findings underscore the necessity for clinicians not only to assess depression in the acute recovery stage, but also to keep in mind the impact of these depressive symptoms on memory and executive functions as well as on subjective complaints.

Despite the strong association between depression and all aspects of objective cognitive performance, attention/processing speed was best predicted by self-reported executive dysfunction, albeit bivariate correlations revealed a similarly strong association between depressive symptoms and attention/processing speed as well. It is important to note that the subjective Executive Dysfunction subscale of the FrSBe not solely is composed of executive dysfunction complaints (e.g., poor planning, impulsivity, disorganization, poor problem solving, inflexibility), but also includes complaints associated with attention (e.g., inattention/lack of concentration) and memory (e.g., forgetfulness). Therefore, it is reasonable to generalize that attention/processing speed performance is associated with subjective cognitive complaints *in general* and not just those complaints associated with executive dysfunction. This finding is important in that it suggests that mild-moderate acute-recovery TBI patients who complain of poor cognition may indeed have poorer performances in the areas of attention/processing speed that cannot be better accounted for by depressive symptomatology. In addition, this finding is consistent with studies that have shown that self-reported cognitive complaints are associated with at least some aspects of

cognitive performance, such as memory, sustained attention, and executive function over and above the effects of depression (Bohnen et al., 1995; Chamelien & Feinstein, 2006). In contrast, Brenner et al. (2010) did not find associations between mild TBI symptoms and neuropsychological performance. As Brenner et al. studied blast-injured veterans, and our sample consisted only of blunt-force noncombat injuries, it is feasible that differing injury mechanisms or combat exposure may play a role in the relationship between subjective and objective symptoms. In sum, there appears to be merit to the subjective cognitive complaints of our TBI sample, suggesting that a “good old days” bias pertaining to a decrement in cognitive difficulties post injury may not be a bias per se but rather may have some relationship to cognitive abilities related to attention/processing speed.

Similar to previous studies that examined postconcussive symptoms in mild TBI (Iverson et al., 2010), individuals who performed below cutoff scores on at least one measure of effort endorsed greater subjective complaints and performed more poorly on cognitive tasks than did those who performed above suggested cutoffs on both effort measures. When individuals with questionable effort were excluded from analyses, the strength of the majority of relationships among cognition, subjective behavioral complaints, and mood diminished, whereas the relationship among subjective behaviors related to apathy, disinhibition, and executive dysfunction remained strongly associated with depression. These results suggest that individuals with poor effort on cognitive testing may endorse greater mood and subjective complaints, resulting in a strong, and possibly over inflated, association among these symptoms. Effort appears to be a strong modulator of the relationship between memory and subjective behavioral and mood complaints, as these relationships were nonsignificant when suboptimal effort individuals were excluded from analyses. However, depression remained a significant predictor of objective executive functioning, whereas subjective executive dysfunction (or general cognitive complaints as discussed above) was the best predictor of objective attention/processing speed. Bivariate correlations revealed that, although depression was significantly related to attention/processing speed as well, subjective executive dysfunction had a significantly greater association with attention/processing speed. These findings suggest that effort plays an important role in the relationship among subjective behavioral symptoms, cognition, and mood. Furthermore, by controlling for suboptimal effort, the relationship between objective and subjective complaints is clarified such that depression best predicts objective executive function, whereas subjective cognitive complaints are best associated with objective attention/processing speed.

It was beyond the scope of our study to assess whether these subjective behavioral symptoms or cognitive complaints are a direct manifestation of structural or functional changes associated with TBI. However, it is well known that the frontal cortex is most often affected by TBI (Levin, 1987) and is associated with executive functions as well as the self-regulation of behavior, such as decision making and response inhibition (Beer, John, Scabini, & Knight, 2006; Mega & Cummings, 1994). Moreover, a recent imaging study implicated the superior medial frontal cortex in the performances of traumatic-brain-injured individuals on tasks of attention, working memory, executive function, and behavioral self-regulation (Fujiwara, Schwartz, Gao, Black, & Levine, 2008). The medial frontal cortex may represent an important region of interest in the intersection between subjective and objective complaints associated with TBI. Further investigation into associations between the neurobiological underpinnings of subjective versus objective symptoms would be informative.

There were several limitations to our study that should be noted. First, while we examined self-reported behaviors pre- and post-injury, this study was not based on longitudinal data, but rather examined the participants’ ability to estimate their preinjury behavior after they

had sustained a TBI. Therefore, it cannot be determined conclusively if the participants' retrospective reports are an accurate reflection of their actual preinjury behavior. Further, although we examined behavioral change in the early stages of recovery in an attempt to better characterize this particular cohort, findings are limited to relationships between TBI-related cognitive/emotional symptoms and behavior in the immediate aftermath of neurotrauma. Future research aimed at examining these relationships longitudinally will be important as behavioral, emotional, and cognitive symptoms of TBI often change over time (Christensen et al., 2008; Frencham et al., 2005). In addition, we characterized the majority of TBI severity levels based on subjective report; unfortunately, this is a well-known and not easily remedied limitation in military and mild TBI populations. Finally, while our use of a relatively homogenous group is beneficial in terms of characterizing this specific group, it limits the generalizability of our results to other populations, such as individuals with severe TBI or individuals with other neurological conditions.

In summary, our results suggest that, in individuals in early recovery from mild to moderate TBI, self-reported depressive symptoms, rather than patients' complaints of executive dysfunction, are associated with objective executive function and memory performance. Depressive symptomatology continued to be the best predictor of executive function performance when suboptimal effort was controlled, and the relationships between memory performance and subjective symptoms were no longer significant. In contrast, attention/processing speed performance was best predicted by subjective cognitive complaints, regardless of effort performance. Our findings buttress the importance of screening for mood disturbance in mild to moderate TBI patients with cognitive complaints, evaluating effort in relation to TBI symptoms, and considering the significant relationship between subjective complaints and objectively assessed attention/processing speed in acute-recovery mild to moderate TBI patients.

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References

- Allen CC, Ruff RM. Self-rating versus neuropsychological performance of moderate versus severe head-injured patients. *Brain Injury*. 1990; 4(1):7–17. [PubMed: 2297602]
- American Psychiatric Association. Diagnostic and statistical manual of mental disorders. 4. Washington, DC: Author; 1994.
- Andersson S, Bergedalen AM. Cognitive correlates of apathy in traumatic brain injury. *Neuropsychiatry, Neuropsychology, and Behavioral Neurology*. 2002; 15:184–191.
- Arciniegas DB, Held K, Wagner P. Cognitive impairment following traumatic brain injury. *Current Treatment Options in Neurology*. 2002; 4(1):43–57. [PubMed: 11734103]
- Bay E, Donders J. Risk factors for depressive symptoms after mild-to-moderate traumatic brain injury. *Brain Injury*. 2008; 22:233–241. [PubMed: 18297595]
- Beck AT, Ward CH, Mendelson M, Mock J, Erbaugh J. An inventory for measuring depression. *Archives of General Psychiatry*. 1961; 4:561–571. [PubMed: 13688369]

- Beer JS, John OP, Scabini D, Knight RT. Orbitofrontal cortex and social behavior: Integrating self-monitoring and emotion–cognition interactions. *Journal of Cognitive Neuroscience*. 2006; 18(6): 871–879. [PubMed: 16839295]
- Binder LM, Storzbach D, Anger WK, Campbell KA, Rohlman DS. and other members of the Portland Environmental and Hazards Research Center. Subjective cognitive complaints, affective distress, and objective cognitive performance in Persian Gulf War veterans. *Archives of Clinical Neuropsychology*. 1999; 14(6):531–536. [PubMed: 14590580]
- Bohnen N, Jolles J, Twijnstra A. Neuropsychological deficits in patients with persistent symptoms six months after mild head injury. *Neurosurgery*. 1992; 30(5):692–695. discussion 695–696. [PubMed: 1584379]
- Bohnen NI, Jolles J, Twijnstra A, Mellink R, Wijnen G. Late neurobehavioural symptoms after mild head injury. *Brain Injury*. 1995; 9(1):27–33. [PubMed: 7874093]
- Bombardier CH, Fann JR, Temkin NR, Esselman PC, Barber J, Dikmen SS. Rates of major depressive disorder and clinical outcomes following traumatic brain injury. *JAMA: The Journal of the American Medical Association*. 2010; 303(19):1938–1945. [PubMed: 20483970]
- Brenner LA, Terrio H, Homaifar BY, Gutierrez PM, Staves PJ, Harwood JE, et al. Neuropsychological test performance in soldiers with blast-related mild TBI. *Neuropsychology*. 2010; 24(2):160–167. [PubMed: 20230110]
- Burt DB, Zembar MJ, Niederehe G. Depression and memory impairment: A meta-analysis of the association, its pattern, and specificity. *Psychological Bulletin*. 1995; 117(2):285–305. [PubMed: 7724692]
- Chamelian L, Feinstein A. The effect of major depression on subjective and objective cognitive deficits in mild to moderate traumatic brain injury. *Journal of Neuropsychiatry and Clinical Neurosciences*. 2006; 18(1):33–38. [PubMed: 16525068]
- Christensen BK, Colella B, Inness E, Hebert D, Monette G, Bayley M, et al. Recovery of cognitive function after traumatic brain injury: A multilevel modeling analysis of Canadian outcomes. *Archives of Physical Medicine and Rehabilitation*. 2008; 89(12 Suppl):S3–S15. [PubMed: 19081439]
- Defense and Veterans Brain Injury Center. Defense and Veterans Brain Injury Center fact sheet. Washington, DC: Walter Reed Army Medical Center; 2007.
- Defense and Veterans Brain Injury Center. Department of Defence Numbers for Traumatic Brain Injury; 2010. Available from <http://www.dvbic.org/TBI-Numbers.aspx>
- Delis, DC.; Kaplan, E.; Kramer, JH. Delis–Kaplan Executive Function System: Examiner’s manual. San Antonio, TX: The Psychological Corporation; 2001.
- Delis, D.; Kramer, J.; Kaplan, E.; Ober, B. California Verbal Learning Test: Adult Version manual. 2. San Antonio, TX: Psychological Corporation; 2000.
- Drake AI, Gray N, Yoder S, Pramuka M, Llewellyn M. Factors predicting return to work following mild traumatic brain injury: A discriminant analysis. *Journal of Head Trauma Rehabilitation*. 2000; 15(5):1103–1112. [PubMed: 10970931]
- Frencham KA, Fox AM, Maybery MT. Neuropsychological studies of mild traumatic brain injury: A meta-analytic review of research since 1995. *Journal of Clinical and Experimental Neuropsychology*. 2005; 27(3):334–351. [PubMed: 15969356]
- Fujiwara E, Schwartz ML, Gao F, Black SE, Levine B. Ventral frontal cortex functions and quantified MRI in traumatic brain injury. *Neuropsychologia*. 2008; 46(2):461–474. [PubMed: 17976665]
- Gass CS, Apple C. Cognitive complaints in closed-head injury: Relationship to memory test performance and emotional disturbance. *Journal of Clinical and Experimental Neuropsychology*. 1997; 19(2):290–299. [PubMed: 9240487]
- Grace, J.; Malloy, P. Frontal Systems Behavior Scale: Professional manual. Lutz, FL: Psychological Assessment Resources; 2001.
- Han SD, Drake AI, Cessante LM, Jak AJ, Houston WS, Delis DC, et al. Apolipoprotein E and traumatic brain injury in a military population: Evidence of a neuropsychological compensatory mechanism? *Journal of Neurology, Neurosurgery, and Psychiatry*. 2007; 78(10):1103–1108.

- Han SD, Suzuki H, Drake AI, Jak AJ, Houston WS, Bondi MW. Clinical, cognitive, and genetic predictors of change in job status following traumatic brain injury in a military population. *Journal of Head Trauma Rehabilitation*. 2009; 24(1):57–64. [PubMed: 19158597]
- Hanks RA, Temkin N, Machamer J, Dikmen SS. Emotional and behavioral adjustment after traumatic brain injury. *Archives of Physical Medicine and Rehabilitation*. 1999; 80(9):991–997. [PubMed: 10488997]
- Hoge CW, McGurk D, Thomas JL, Cox AL, Engel CC, Castro CA. Mild traumatic brain injury in U.S. soldiers returning from Iraq. *New England Journal of Medicine*. 2008; 358(5):453–463. [PubMed: 18234750]
- Iverson GL. Misdiagnosis of the persistent postconcussion syndrome in patients with depression. *Archives of Clinical Neuropsychology*. 2006; 21(4):303–310. [PubMed: 16797916]
- Iverson GL, Lange RT, Brooks BL, Rennison VL. “Good old days” bias following mild traumatic brain injury. *The Clinical Neuropsychologist*. 2010; 24(1):17–37. [PubMed: 19830628]
- Jorge RE, Robinson RG, Moser D, Tateno A, Crespo-Facorro B, Arndt S. Major depression following traumatic brain injury. *Archives of General Psychiatry*. 2004; 61(1):42–50. [PubMed: 14706943]
- Kraus JF, McArthur DL. Epidemiologic aspects of brain injury. *Neurologic Clinics*. 1996; 14(2):435–450. [PubMed: 8827181]
- Lange RT, Iverson GL, Rose A. Post-concussion symptom reporting and the “good-old-days” bias following mild traumatic brain injury. *Archives of Clinical Neuropsychology*. 2010; 25(5):442–450. [PubMed: 20447932]
- Lange RT, Iverson GL, Rose A. Depression strongly influences postconcussion symptom reporting following mild traumatic brain injury. *Journal of Head Trauma Rehabilitation*. 2011; 26(2):127–137. [PubMed: 20631632]
- Lannoo E, Colardyn F, Vandekerckhove T, De Deyne C, De Soete G, Jannes C. Subjective complaints versus neuropsychological test performance after moderate to severe head injury. *Acta Neurochirurgica (Wien)*. 1998; 140(3):245–253.
- Levin, HS., editor. *Neurobehavioral sequelae of head injury*. Baltimore, MD: Williams and Wilkins; 1987.
- Massman PJ, Delis DC, Butters N, Dupont RM, Gillin JC. The subcortical dysfunction hypothesis of memory deficits in depression: Neuropsychological validation in a subgroup of patients. *Journal of Clinical and Experimental Neuropsychology*. 1992; 14(5):687–706. [PubMed: 1474139]
- Mathias CW, Greve KW, Bianchini KJ, Houston RJ, Crouch JA. Detecting malingered neurocognitive dysfunction using the reliable digit span in traumatic brain injury. *Assessment*. 2002; 9(3):301–308. [PubMed: 12216787]
- Mega MS, Cummings JL. Frontal-subcortical circuits and neuropsychiatric disorders. *The Journal of Neuropsychiatry and Clinical Neurosciences*. 1994; 6(4):358–370. [PubMed: 7841807]
- Moore BA, Donders J. Predictors of invalid neuropsychological test performance after traumatic brain injury. *Brain Injury*. 2004; 18(10):975–984. [PubMed: 15370897]
- Ottowitz WE, Dougherty DD, Savage CR. The neural network basis for abnormalities of attention and executive function in major depressive disorder: Implications for application of the medical disease model to psychiatric disorders. *Harvard Review of Psychiatry*. 2002; 10(2):86–99. [PubMed: 11897749]
- Prigatano GP. Personality disturbances associated with traumatic brain injury. *Journal of Consulting and Clinical Psychology*. 1992; 60(3):360–368. [PubMed: 1619090]
- Rapoport MJ, McCullagh S, Shammi P, Feinstein A. Cognitive impairment associated with major depression following mild and moderate traumatic brain injury. *Journal of Neuropsychiatry and Clinical Neurosciences*. 2005; 17(1):61–65. [PubMed: 15746484]
- Reid-Arndt SA, Nehl C, Hinkebein J. The Frontal Systems Behaviour Scale (FrSBe) as a predictor of community integration following a traumatic brain injury. *Brain Injury*. 2007; 21(13–14):1361–1369. [PubMed: 18066938]
- Ruff RM, Iverson GL, Barth JT, Bush SS, Broshek DK. Recommendations for diagnosing a mild traumatic brain injury: A National Academy of Neuropsychology education paper. *Archives of Clinical Neuropsychology*. 2009; 24(1):3–10. [PubMed: 19395352]

- Rutland-Brown W, Langlois JA, Thomas KE, Xi YL. Incidence of traumatic brain injury in the United States, 2003. *Journal of Head Trauma Rehabilitation*. 2006; 21(6):544–548. [PubMed: 17122685]
- Sillanpaa MC, Agar LM, Milner IB, Podany EC, Axelrod BN, Brown GG. Gulf War veterans: A neuropsychological examination. *Journal of Clinical and Experimental Neuropsychology*. 1997; 19(2):211–219. [PubMed: 9240481]
- Warden D. Military TBI During the Iraq and Afghanistan Wars. *Journal of Head Trauma Rehabilitation*. 2006; 21(5):398–402. [PubMed: 16983225]
- Warriner EM, Velikonja D. Psychiatric disturbances after traumatic brain injury: Neurobehavioral and personality changes. *Current Psychiatry Reports*. 2006; 8(1):73–80. [PubMed: 16513045]
- Wechsler, D. WAIS–III: Administration and scoring manual. 3. San Antonio, TX: Psychological Corporation; 1997a. Wechsler Adult Intelligence Scale.
- Wechsler, D. WMS–III: Administration and scoring manual. 3. San Antonio, TX: Psychological Corporation; 1997b. Wechsler Memory Scale.
- Wechsler, D. Wechsler Abbreviated Scale of Intelligence (WASI). San Antonio, TX: The Psychological Corporation; 1999.

Figure 1.

FrSBe (Frontal Systems Behavior Scale) Apathy, Behavioral Disinhibition, and Subjective Executive Dysfunction subscale T-scores pre- and post-TBI.

Note: * = significant differences between pre- and post-TBI scores at $p < .001$.

TABLE 1

Summary of composites and factor scores from a principal component analysis with orthogonal (varimax) rotation

	Factor scores from PCA with OR		
	1	2	3
Cognitive composite			
Memory	.928	.245	.281
Executive Function	.253	.913	.321
Attention/Processing Speed	.311	.342	.887

Note. PCA = principal component analysis. OR = orthogonal rotation.

TABLE 2

Demographic information for the entire TBI sample

Demographic variables	Mean (SD)	Range
Age (years)	25.4 (6.2)	18–45
Sex (M:F)	66:5	—
Education (years)	12.9 (1.8)	11–20
Rank ^a	4.7 (2.6)	E1–O3/W4
Days from injury	38.3 (11.8)	17–63

Note. TBI = traumatic brain injury. M = male. F = female. $n = 71$.

^aRank was converted into numeric form by assigning 1–9 for Ranks E1–E9, 10 for Ranks W1 and O1, 11 for Ranks W2 and O2, 12 for Ranks W3 and O3, and 13 for Ranks W4 and O4.

TABLE 3

Neuropsychological test score means, standard deviations, and ranges

Test scores	Mean (SD)	Range
Digit Span total (WAIS–III)	9.5 (2.5)	5–19
Digit Symbol total (WAIS–III)	9.4 (2.7)	4–15
Visual Reproduction II Recall (WMS–III)	10.1 (3.5)	3–19
Visual Reproduction II Recognition (WMS–III)	10.4 (3.1)	2–14
CVLT–II Long Delay Free Recall	6.7 (3.3)	0–14
CVLT–II Recognition Discriminability	7.7 (3.2)	0–13
Matrix Reasoning (WASI)	10.8 (2.7)	1–17
Trail Making Test: Number–Letter Switching (DKEFS)	9.4 (3.1)	1–14
Beck Depression Inventory (raw score)	11.26 (8.6)	0–34

Note. WAIS = Wechsler Adult Intelligence Scale; WMS = Wechsler Memory Scale; CVLT–II = California Verbal Learning Test–Second Edition; WASI = Wechsler Abbreviated Scale of Intelligence; DKEFS = Delis–Kaplan Executive Function System; all scores are scaled (standardized) scores unless otherwise noted; $n = 71$.

TABLE 4

Comparisons between mild versus moderate TBI on behavioral, cognitive, and mood measures

	Mild TBI (n = 44)	Moderate TBI (n = 22)	
	Mean (SD)	Mean (SD)	p-value
<i>FrSBe</i>			
Pre-injury			
Apathy	40.1 (12.4)	39.9 (10.3)	.94
Behavioral Disinhibition	47.5 (14.2)	47.3 (12.9)	.96
Subjective Executive Dysfunction	45.4 (15.8)	47.6 (13.1)	.56
Post-injury			
Apathy	54.8 (17.1)	67.6 (17.9)	<.01
Behavioral Disinhibition	52.8 (14.8)	52.8 (9.4)	.98
Subjective Executive Dysfunction	56.1 (19.9)	69.2 (18.9)	.01
Pre- to post-injury change			
Apathy	14.7 (17.2)	27.8 (16.8)	<.01
Behavioral Disinhibition	5.3 (7.8)	5.5 (11.2)	.92
Subjective Executive Dysfunction	10.8 (14.2)	21.6 (18.3)	.01
<i>Self-reported depressive symptoms</i>			
Beck Depression Inventory	8.9 (7.1)	15.0 (9.1)	<.01
<i>Cognitive composite score</i>			
Attention/Processing Speed ^a	9.8 (1.9)	8.5 (2.0)	<.01
Executive Function ^a	10.4 (2.2)	9.5 (3.0)	.13
Memory ^a	9.0 (2.4)	7.7 (2.8)	.04

Note. TBI = traumatic brain injury. FrSBe = Frontal Systems Behavior Scale. All FrSBe scores are self-reported *t*-scores; FrSBe change scores = *t*-score increases from before (pre) to after (post) TBI (positive numbers represent an endorsement of greater behavioral problems).

^a Attention/Processing Speed, Executive Function, and Memory are represented as objectively measured composite scaled scores.

TABLE 5

Intercorrelations for behavior, cognitive, mood, and severity variables

	1	2	3	4	5	6	7
1 Objective Attention/Processing Speed composite ^a	—	—	—	—	—	—	—
2 Objective Executive Function composite ^a	.68***	—	—	—	—	—	—
3 Objective Memory composite ^a	.62***	.55***	—	—	—	—	—
4 Self-reported Apathy (FrSBe) ^b	-.41***	-.26*	-.31**	—	—	—	—
5 Self-reported Behavioral Disinhibition (FrSBe) ^b	-.26*	-.23	-.14	.48***	—	—	—
6 Self-reported Executive Dysfunction (FrSBe) ^b	-.44***	-.34**	-.37**	.83***	.65***	—	—
7 Self-reported Depression (BDI)	-.43***	-.37**	-.42***	.65***	.41***	.69***	—
8 TBI severity (mild vs. moderate)	-.23*	-.21	-.21	.24*	-.09	.12	-.24*

Note. *n* = 68 (3 participants were not administered all the tests due to time constraints). TBI = traumatic brain injury. FrSBe = Frontal Systems Behavior Scale. BDI = Beck Depression Inventory.

^a Attention/Processing Speed, Executive Function, and Memory are represented as objectively measured composite scaled scores.

^b FrSBe subscales are represented as “after/post-TBI” *t*-scores.

* *p* < .03.

** *p* < .01.

*** *p* < .001.

TABLE 6
Comparisons between optimal effort and suboptimal effort groups on behavioral, cognitive, and mood measures

	Optimal effort (n = 56)		Suboptimal effort (n = 15)		p-value
	M	SD	M	SD	
FrSBe					
Pre-injury					
Apathy	41.1	12.3	37.7	11.9	.33
Behavioral Disinhibition	48.1	13.8	44.2	11.8	.33
Subjective Executive Dysfunction	47.4	16.1	44.2	13.8	.49
Post-injury					
Apathy	56.7	18.0	69.7	17.9	.02
Behavioral Disinhibition	51.9	13.9	54.2	9.5	.55
Subjective Executive Dysfunction	57.6	20.9	73.1	18.6	.01
Pre- to post-injury change					
Apathy	15.6	16.3	32.0	18.5	<.001
Behavioral Disinhibition	3.8	6.8	10.0	13.2	.10
Subjective Executive Dysfunction	10.2	13.3	28.9	22.0	<.01
Self-reported depressive symptoms					
Beck Depression Inventory	9.6	7.4	17.4	9.9	<.001
Cognitive composite score					
Attention/Processing Speed ^a	10.0	1.8	7.3	1.7	<.001
Executive Function ^a	10.6	2.2	8.0	2.9	<.001
Memory ^a	9.4	2.3	6.0	2.5	<.001

Note. TBI = traumatic brain injury. FrSBe = Frontal Systems Behavior Scale. All FrSBe scores are self-reported *t*-scores; FrSBe change scores = *t*-score increases from before (pre) to after (post) TBI (positive numbers represent an endorsement of greater behavioral problems).

^a Attention/Processing Speed, Executive Function, and Memory are represented as objectively measured composite scaled scores.

Intercorrelations for behavior, cognitive, mood, and severity variables excluding individuals who scored below RDS or CVLT-II forced-choice cutoff scores

TABLE 7

	1	2	3	4	5	6	7
1 Objective Attention/Processing Speed composite ^a	—	—	—	—	—	—	—
2 Objective Executive Function composite ^a	.56***	—	—	—	—	—	—
3 Objective Memory composite ^a	.52***	.47***	—	—	—	—	—
4 Self-reported Apathy (FrSBe) ^b	-.35**	-.22	-.13	—	—	—	—
5 Self-reported Behavioral Disinhibition (FrSBe) ^b	-.29*	-.23*	-.11	.52***	—	—	—
6 Self-reported Executive Dysfunction (FrSBe) ^b	-.37**	-.26*	-.21	.83***	.67***	—	—
7 Self-reported Depression (BDI)	-.30**	-.27*	-.18	.69***	.50***	.69***	—
8 TBI severity (mild vs. moderate)	-.07	-.04	-.11	.15	-.11	.14	-.15

Note. $N = 56$. TBI = traumatic brain injury. FrSBe = Frontal Systems Behavior Scale. RDS = Reliable Digit Span. CVLT-II = California Verbal Learning Test-Second Edition. BDI = Beck Depression Inventory.

^a Attention/Processing Speed, Executive Function, and Memory are represented as objectively measured composite scaled scores.

^b FrSBe subscales are represented as "after/post-TBI" t -scores.

* $p < .05$.

** $p < .01$.

*** $p < .001$.