The Association Between PTSD and Functional Outcome Is Mediated by Perception of Cognitive Problems Rather Than Objective Neuropsychological Test Performance


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Posttraumatic stress disorder (PTSD) has been consistently linked to poorer functional outcomes, including quality of life, health problems, and social and occupational functioning. Less is known about the potential mechanisms by which PTSD leads to poorer functional outcomes. We hypothesized that neurocognitive functioning and perception of cognitive problems would both mediate the relationship between PTSD diagnosis and functioning. In a sample of 140 veterans of the recent wars and conflicts in Iraq and Afghanistan, we assessed PTSD symptoms, history of traumatic brain injury (TBI), depression, self-report measures of quality of life, social and occupational functioning, and reintegration to civilian life, as well as perception of cognitive problems. Veterans also completed a comprehensive neuropsychological battery of tests. Structural equation modeling revealed that perception of cognitive problems, but not objective neuropsychological performance, mediated the relationship between PTSD diagnosis and functional outcomes after controlling for TBI, depression, education, and a premorbid IQ estimate, showing a large effect size. These results highlight the importance of addressing appraisals of posttrauma cognitive functioning in treatment as a means of improving functional outcomes.
Research on individuals with PTSD (Geuze, Vermetten, de Kloet, Hijman, & Westenberg, 2009; Wrocklage et al., 2016), depression (Buist-Bouwman et al., 2008; McCall & Dunn, 2003), and psychotic disorders (Green, Kern, Braff, & Mintz, 2000; Twamley et al., 2002) has demonstrated that cognitive deficits are associated with social and occupational functioning impairments. Geuze et al. (2009) found that PTSD patients’ complaints of memory and attention problems were negatively correlated with test performance but associated with self-reported functional impairment. Wrocklage et al. (2016) reported differences in processing speed and executive functioning tasks between veterans with and without PTSD, and reported that executive functioning impairment was associated with self-reported functional and physical outcomes. Meditational studies with depression indicate that cognitive deficits may account for the largest percentage of variance in psychosocial outcomes, most notably work performance (McIntyre et al., 2013). However, neither neurocognitive performance nor the perception of cognitive impairment have been examined as mediators in the relationship between PTSD and functional outcomes. Both observed and perceived difficulties with memory, attention, thinking, and decision-making related to PTSD have the potential to cause greater difficulties in the social and occupational arenas.

The present study examined relationships between PTSD and functional outcomes, testing subjective and objective cognitive functioning as mediators. We hypothesized that both subjective and objective cognitive functioning would exert indirect effects on the relationships between PTSD and functional outcomes, such that difficulties in social, physical, and emotional functioning would be partially explained by difficulties in cognitive functioning. In order to model effects of PTSD while controlling for potentially confounding diagnoses as well as education and premorbid estimate of intelligence, these models were conducted covarying for TBI history, depressive symptoms, and vocabulary and years of education. Both TBI (e.g., French, Lange, & Brickell, 2014; Kontos et al., 2013) and depression (e.g., Lee et al., 2012) are associated with neurocognitive deficits and perception of cognitive problems, so including them in the model as covariates allowed for examination of the unique effects of PTSD over and above those found for TBI and depression. In addition, education and intelligence are associated with other domains of neurocognitive functioning (e.g., Tremont, Hoffman, Scott, & Adams, 1998), as well as PTSD (e.g., McNally & Shin, 1995), so to examine effects of PTSD on cognitive functioning independent of those two confounding factors we included them as covariates.

Method

Participants and Procedure

Male and female veterans of the recent wars and conflicts in Iraq and Afghanistan, ranging in age from 18 to 60 years, were recruited from the San Francisco Veterans Administration
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Veterans and the community through media advertise-
ments. There were 220 veterans screened by telephone to
determine study eligibility; 189 participated in the initial in-
person assessment and 140 completed the study and met allinclusion requirements. The study protocol and consent form
was approved by the Committee on Human Research, Uni-
versity of California, San Francisco and the Human Research
Protection Program at the San Francisco VA Medical Center.

Exclusionary criteria assessed at phone screening included
poor English comprehension; undergoing neurocognitive re-
habilitation or testing within the past year; diagnosis of brain
tumor, advanced HIV, chronic kidney disease, liver disease,
and/or stroke; and report of medical diagnosis of moderate or
severe TBI or report of loss of consciousness due to head injury
of greater than 30 minutes, or diagnosis of psychotic disor-
der or bipolar disorder. Exclusionary criteria determined at the
time of the clinical interview and neuropsychological testing
included lifetime history of psychotic disorder or bipolar dis-
order or current diagnosis of alcohol or drug dependence,
assessed through the Structured Clinical Interview for DSM-IV
Diagnosis (SCID; First, Spitzer, Gibbon, & Williams, 1997),
subthreshold PTSD, and suspected poor effort or malingering
based on Test of Memory Malingering (TOMM; Tombaugh,
1996) performance, as defined by scores ≤ 41 on Trial 1. There
were two participants who failed the TOMM screen, and five
participants were excluded following the clinical interview due
to diagnoses of psychotic disorder (n = 1) and substance de-
pendence (n = 4). Additionally, 19 participants were excluded
due to having subthreshold, but not full, PTSD, and 18 par-
participants dropped out before completing neuropsychological
assessments.

Measures

PTSD, depression, and TBI. Veterans were adminis-
tered the Life Stressor Checklist (LSC; Wolfe, Kimerling, Brown,
Chrestman, & Levin, 1996) to identify possible Criterion A
events, based on the Diagnostic and Statistical Manual of Men-
tal Disorders (4th ed., txt rev.; DSM-IV-TR; American Psy-
chiatric Association [APA], 2000) that participants may have
been exposed to in their lifetime. The Clinician Administered
PTSD Scale (CAPS; Blake et al., 1995) was then administered;
veterans answered questions regarding their worst Criterion A
event. A full diagnosis of PTSD was given if the participant
experienced a Criterion A event and one or more Cluster B
symptoms (reexperiencing), three or more symptoms in Cluster
C (avoidance), and two or more symptoms in Cluster D
(hyperarousal). The Patient Health Questionnaire–9 (PHQ-9;
Kroenke & Spitzer, 2002) was used as a brief self-report mea-
sure of major depressive symptoms.

Veterans were administered the VA TBI Screening Tool
(VATBIST; Donnelly et al., 2011) by interview. The VATBIST
is a 4-item measure including questions assessing potential
TBI-causing event (blast or explosion, vehicle crash, fragment
or bullet wound above the shoulders, fall, or blow to head),
loss or alteration of consciousness including being dazed or
confused or not remembering the event, and postconcussive
symptoms both at the time of event and currently (including
memory problems, balance problems, sensitivity to light, irri-
tability, headaches, and sleep problems). Endorsement of all
four items is indicative of a positive TBI screen indicating TBI
history as well as current postconcussive symptoms.

Objective cognitive functioning. Veterans were adminis-
tered a comprehensive neuropsychological battery that included
multiple measures assessing neurocognitive skills previously
found to be impaired in PTSD including verbal learning and
memory, visual learning and memory, working memory, pro-
cessing speed, and executive functioning.

To assess immediate verbal memory and learning, we used
the Hopkins Verbal Learning Test (HVLT; Brandt, 1991) total
score and the Verbal Paired Associates (VPA) I score of the
Wechsler Memory Scale (WMS-III; Wechsler, 1997). To assess
delayed verbal memory, we used the HVLT delayed recall score
and the VPA II score, both of which are administered 20 minutes
after the immediate learning task.

To assess immediate and delayed visual memory, the Brief
Visual Memory Test–Revised (BVMT-R; Benedict, 1997) and
Rey-Osterrieth Complex Figure Test (ROCF; Rey, 1944) were
used. The BVMT-R immediate recall score and ROCF imme-
mediate recall score are measures of recall and reproduction of
visual figures and the delayed scores of each task are measures
of recall and reproduction after a delay of 20 to 25 minutes.

Working memory was assessed using the Digit Span and
Arithmetic subtests of the Wechsler Adult Intelligence Scale
(WAIS-IV; Wechsler, Cowan, & Raiford, 2008). Digit Span
requires participants to repeat digits forwards, backwards,
and sequences in ascending order; the combined score of these
three tasks was used. The Arithmetic task requires examinees
to mentally solve a series of arithmetic problems.

To assess processing speed, we administered two timed tasks,
the Coding and Symbol Search subtests of the WAIS-IV, which
constitute the processing speed index. Both measures require
the test taker to reproduce or scan and match symbols quickly,
efficiently, and accurately.

Multiple measures were administered to assess for subdo-
mains of executive functioning including fluency, planning and
problem solving, and set shifting and inhibitory control. To
assess visual fluency, we administered the Design Fluency sub-
test of the Delis-Kaplan Executive Function System (D-KEFS;
Delis, Kaplan, & Kramer, 2001). Planning and problem solving
were assessed through the D-KEFS Tower Test. Total scores for
these measures were used in analyses. Set shifting, inhibitory
control, and cognitive flexibility were assessed with subscores
of the D-KEFS Color-Word Interference Test and Trail Making
Test (Reitan, 1992). For Color-Word, the Inhibition/Switching
task score was used, and for Trails we used the difference score
of Part B–Part A.

Veterans were also administered the Vocabulary subtest of
the WAIS-IV, which was used as an estimate of intellectual
functioning. The Vocabulary subtest is often used as a “hold” test from which estimates of premorbid functioning are derived in brain-injured populations (Lezak, Howieson, Bigler, & Tranel, 2012). Finally, veterans were administered TOMM (Tombaugh, 1996) as a measure of performance validity. Veterans who received scores \( r = 41 \) on Trial 1 \((n = 2)\) were excluded from analyses (Denning, 2012).

**Subjective cognitive functioning.** Veterans were administered the Neurobehavioral Symptom Inventory (NSI; Cicerone & Kalmar, 1995), a 22-item self-report measure of postconcussive symptoms that includes a Cognitive subscale of symptoms related to cognitive complaints (poor concentration, forgetfulness, difficulty making decisions, and slowed thinking). Although designed for the assessment of postconcussive symptoms, the symptoms are also relevant to patients with PTSD (Soble et al., 2014). The NSI has high internal consistency and scale validity (King & Wray, 2012). Cronbach’s alpha for internal consistency of the NSI Cognitive subscale for this sample was .87. The NSI Validity-10 scale is an embedded validity scale that assesses for symptom overreporting or exaggeration (Vanderploeg et al., 2014). The authors recommend a cut score of \( \geq 23 \) as likely of an exaggerated profile (Vanderploeg et al., 2014). None of the veterans in the current study received Validity-10 scores \( \geq 23 \).

**Functional outcomes.** To assess perceived levels of functional impairment related to physical and mental health, participants were given the Short Form Health Survey (SF-12; Gandek et al., 1998), which is a condensed version of the Short Form Survey–36 (SF-36). The SF-36 has excellent validity and reliability (Brazier et al., 1992) and correlations between the SF-36 and SF-12 are high \((rs = .94 \text{ to } .96; \text{ Gandek et al., 1998})\). Cronbach’s alpha for internal consistency for this sample was .90. The SF-12 produces physical and mental health composite scores and contains three specific subscales related to role limitations due to emotional problems, physical health problems, and social functioning problems. These subscales were used in the current study.

The Military to Civilian Questionnaire (M2C-Q; Sayer et al., 2011) assessed levels of postdeployment reintegration difficulty. The M2C-Q is a 16-item self-report measure that has been shown to have high internal consistency and construct validity in a sample of 1,226 Iraq and Afghanistan veterans (Sayer et al., 2011). Cronbach’s alpha for internal consistency for this sample was .94.

**Data Analysis**

To test the hypothesis that both perception of cognitive problems and objective neurocognitive performance mediate the relationship between PTSD status (independent variable) and functional outcomes (dependent variable), we employed structural equation modeling (SEM; see Figure 1) via maximum likelihood estimation. This approach permits estimation of direct and indirect effects with a latent variable outcome, which in this case consisted of physical, emotional, and social functioning, and reintegration. This approach was chosen in lieu of testing each outcome separately because of the high collinearity between the dependent variables, and eliminated the need for multiple hypothesis testing. Significance of the indirect effects was evaluated through bias-corrected bootstrapping with 1,000 replications; bootstrapping is considered more powerful for evaluating the significance of indirect effects than other methods (MacKinnon, Lockwood, & Williams, 2004). Indirect effects were considered significant if the 95% bias-corrected bootstrapped confidence intervals did not contain zero. Overall model fit was evaluated by traditional SEM fit indices; specifically, the root mean square error of approximation (RMSEA), comparative fit index (CFI), and standardized root mean squared residual (SRMR). An RMSEA of \( \leq .06 \), CFI \( \geq .95 \), and SRMR \( \leq .08 \) suggests that the model has adequate fit to the data (Hu & Bentler, 1999). Because there was a large number of neuropsychological tests administered that measured overlapping neurocognitive domains (e.g., verbal learning), principal components analysis (PCA) was conducted prior to the structural equation model to use neurocognitive components, thereby reducing the number of mediators in the model that were potentially redundant. This approach was taken rather than creating latent neurocognitive components within the structural equation model to (a) reduce the number of parameters in the model to conserve power, and (b) to use an agnostic data-driven approach. The number of components retained was determined via parallel analysis with 1,000 simulations of the raw data (Horn, 1965), with components considered meaningful if they exceeded the mean simulated eigenvalue. Oblique (promax) rotation was used, because neurocognitive domains were expected to correlate, and tests were considered to be part of a specific component if they had a loading \( \geq .40 \).

Results of the parallel analysis indicated that four components existed (see Supplementary Table 1), which were comprised of visual learning and memory (BVMT-R and ROCF immediate and delayed trials), verbal learning and memory (HVLT-R and VPA immediate and delayed trials), processing speed/fluency (design fluency, coding, symbol search), and executive functioning (Digit Span, Arithmetic, Towers, Trails, B–A). As expected, all components were associated with one another, with the exception of executive functioning and processing speed/fluency, \( r = .11, p = .165 \). Visual and verbal learning and memory were strongly associated, \( r = .39, p < .001 \), while verbal learning and memory was also associated with executive functioning, \( r = .21, p = .011 \), and processing speed/fluency, \( r = .35, p < .001 \). Visual learning and memory was associated with executive functioning, \( r = .24, p = .003 \), and processing speed/fluency, \( r = .17, p = .031 \). Latent scores of the components for each subject were generated by regressions based on the component weightings, which were used as indirect effects within the SEM. Depression severity, TBI status, years of education, and vocabulary score were included
as covariates of the cognitive components, and residuals of the proposed mediators were allowed to correlate in the model. Because depression and PTSD share several symptoms, we constructed a residualized variable of PHQ depression which partials out shared variance with the CAPS and used this residualized variable in the model, a technique used in prior studies (Samuelson et al., 2006). All analyses were conducted in Stata version 14.0 (StataCorp, 2015).

Results

Demographic information can be found in Table 1, and a breakdown of demographics by PTSD status can be found in Supplementary Table 2. Forty percent of the veterans had a full diagnosis of PTSD and 37.7% had positive VATBIST screens. Participants were between the ages of 23 and 57 years ($M = 36.13, SD = 8.68$), were ethnically diverse (46.4% Caucasian; 20.7% Asian American, 16.4% Hispanic, and 3.6% African American), and predominantly male (82.9%). Estimated premorbid functioning as measured by the WAIS-IV Vocabulary subtest was nearly two-thirds of a standard deviation above population norms ($M = 11.65, SD = 3.16$). Complete data was available for 132 subjects; because of the high percentage of complete cases (94%), we did not implement a missing data estimator.

Goodness-of-fit indices for the structural equation model indicated good model fit overall, $\chi^2 = 47.301, p = .064$, RMSEA = .054, CFI = .982, Tucker-Lewis index (TLI) = .957, and SRMR = .032. Parameter estimates of the SEM can be found in Supplementary Table 3, with significant paths shown in Figure 1. In terms of primary associations between PTSD status and the proposed mediators, PTSD was independently associated with greater perceived cognitive problems, $\beta = .54, p < .001$, as well as worse executive functioning, $\beta = -.18, p = .029$, but was not associated with the other objective cognitive components, $p_s = .402$ to .974. Posttraumatic stress disorder status predicted functional outcomes, $\beta = -.59, p < .001$, and the only proposed mediator to predict functional outcomes was perceived cognitive problems, $\beta = -.30, p < .001$. No objective cognitive component predicted functional outcomes, $p_s = .117$ to .909.

Consistent with our hypothesis, tests of mediation (see Table 2) revealed a significant indirect effect of perceived cognitive problems for PTSD, $b = -6.29, 95\% \text{ BC CI: } [-11.03, -2.88]$, which corresponds to a large effect size (Preacher & Kelley, 2011). PTSD status maintained a highly significant direct effect on functional outcomes in the model, $b = -23.02, p < .001$. Contrary to our hypothesis, objective neurocognitive performance did not mediate the relationship between PTSD and functional outcomes.

Discussion

Posttraumatic stress disorder is associated with poorer functional outcomes, but little is known about the mechanisms by which PTSD influences functioning. We hypothesized that both
objective neuropsychological performance and perceptions of cognitive functioning would have mediating effects on the relationship between PTSD and functional outcomes. In a sample of 154 recent Iraq and Afghanistan war veterans, after covarying for TBI history, depressive symptoms, education, and a premorbid estimate of IQ, we found that perception of cognitive problems, but not objective neurocognitive performance, exhibited an indirect effect on the relationship between PTSD and a latent construct of functioning that included physical, emotional, and social functioning, and reintegration difficulties. Not surprisingly, PTSD status continued to exert a highly significant main effect after accounting for multiple mediators and predictors, highlighting that PTSD symptoms independent of perceived cognitive difficulties contribute to difficulties in functioning. In addition, PTSD was strongly related to perceptions of cognitive impairment even when controlling for TBI and depression, which have been found in previous studies to be related to perceptions of cognitive impairment (Chamelian and Feinstein, 2006; Drag et al., 2012; Spencer et al., 2010).

These results suggest that it is the perception of memory, attention, and concentration problems posttrauma, as opposed
to objective, neurocognitive performance deficits, that influences social and occupational functioning and reintegration to civilian life. Although PTSD is associated with mild and subtle neurocognitive deficits on performance-based tests (see Scott et al., 2015), these impairments do not appear to exert an effect on functional outcomes to the extent that the subjective experience of cognitive impairment does.

Individuals with PTSD may perceive their cognitive difficulties to be worse than their actual performance demonstrates (Binder et al., 1999). In a recent study, Samuelson et al. (2016) found that posttraumatic cognitions moderated the relationship between PTSD symptoms and perception of cognitive problems, indicating that negative posttraumatic appraisals influence an individual’s perception of memory and attention functioning. In addition, perception of cognitive problems was related to poorer perceived quality of life, over and above the influence of PTSD symptoms. Those findings, coupled with the current results, highlight the influence of one’s appraisals and perceptions of functioning posttrauma on successful reintegration and quality of life. Our findings also add to two theoretical frameworks for understanding posttraumatic cognitions, cognitive theory (Ehlers & Clark, 2000) and social cognitive theory (Benight & Bandura, 2004), which consider the important role of posttrauma appraisals about the self (including guilt and self-blame) and self-efficacy (beliefs about one’s ability to cope with posttraumatic symptoms). We propose that negative appraisals of cognitive functioning represent a specific type of posttrauma performance appraisal.

Several limitations of the study should be noted. First, the data are cross-sectional and limit any causal conclusions. Longitudinal methods can help researchers understand the trajectory of these processes over time, and can provide more causal and directional interpretations. Second, our sample consisted of veterans who responded to research advertisements and were not seen within a clinical setting; as such, they may not be representative of a clinical veteran population that may exhibit more pronounced objective neurocognitive deficits that in turn mediate functional outcomes. Third, it is possible that our cognitive tests may not have been sensitive enough to detect deficits or differences in this sample, although our selection of tests replicates many past studies documenting neurocognitive deficits in PTSD (Scott et al., 2015). It may be that in samples who show more pronounced PTSD-related cognitive performance deficits, there would be a mediational effect of performance on functional outcomes. Fourth, although TBI was not a primary focus of this study, we did include TBI history as a covariate, and its measurement via a screen representing retrospective self-report is not ideal. Finally, we relied on self-report for measures of cognitive problems and functional outcomes. Future research should employ measures of report of significant others, which could aid both researchers and clinicians in receiving a potentially more subjective report of cognitive, social, physical, and emotional problems related to PTSD.

There are important clinical implications of these findings. Trauma-exposed patients often complain to clinicians and health providers of cognitive problems, and providers often struggle with interpreting patient self-report, in part due to inherent bias and inconsistencies. Patients with PTSD may also be aware of the potential impact of their diagnosis on the brain and memory and concentration functioning, and can be especially attuned to perceived changes or deficiencies. Clinicians should be careful not to assume that self-report of cognitive problems equates with objective cognitive deficits, yet be cognizant of their influence on social and occupational functioning. When neuropsychological assessments are conducted, neuropsychologists should be careful to give detailed feedback on the degree (or absence) of impairment as well as its influence on day-to-day functioning. Finally, assisting clients with posttraumatic stress in challenging negative posttraumatic appraisals, including those about cognitive functioning, may be a warranted component of therapy that could influence occupational and social functioning and quality of life.

### Table 2

**Bias-Corrected Bootstrapped Tests of Indirect Effects**

| Variable                  | \( b \)  | Bias-Corrected 95% CI
<table>
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<tbody>
<tr>
<td>NSI Cognition</td>
<td>−6.29*</td>
<td>[−11.03, −2.88]</td>
</tr>
<tr>
<td>Verbal Learning/Memory</td>
<td>−0.13</td>
<td>[−1.12, .31]</td>
</tr>
<tr>
<td>Visual Learning/Memory</td>
<td>−0.01</td>
<td>[−.73, .46]</td>
</tr>
<tr>
<td>Executive Functioning</td>
<td>−0.04</td>
<td>[−.87, .70]</td>
</tr>
<tr>
<td>Processing Speed/Fluency</td>
<td>0.21</td>
<td>[−.21, 1.53]</td>
</tr>
</tbody>
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*Note.* NSI = Neurobehavioral Symptoms Inventory; CI = confidence interval; *95%* confidence intervals are based on 1,000 bias-corrected bootstrapped replications. *\( p < .05 \).


StataCorp (2015). Stata statistical software (Release 14) [Computer software]. College Station, TX: Author.


