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Predictors of Postdeployment Functioning in Combat-Exposed U.S. Military Veterans

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Abstract
Posttraumatic stress disorder (PTSD) and sequelae of mild traumatic brain injury (mTBI) are presumed to contribute to reintegration difficulties in combat-exposed veterans. Yet their relative impacts on postdeployment functioning are not well understood. The current study used structural equation modeling (SEM) to clarify the extent to which symptoms of internalizing disorders (e.g., depression, anxiety), mTBI symptoms, and cognitive performance are associated with functional impairment in 295 combat-exposed veterans. SEM results showed that internalizing symptoms most significantly predicted functional impairment ($r = 0.72$). Blast mTBI and cognitive performance were associated with internalizing ($r = 0.24$ and -0.25, respectively), but functional impairment was only modestly related to cognition ($r = -0.17$) and unrelated to mTBI. These results indicate that internalizing symptoms are the strongest predictor of functioning in trauma-exposed veterans, exceeding the effects of mTBI and cognitive performance. This evidence supports prioritizing interventions that target internalizing psychopathology to improve functioning in cases of co-occurring PTSD and mTBI.

Keywords
trauma, neuropsychology, posttraumatic stress disorder, war

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A common struggle for veterans returning home from combat deployments is problems reintegrating into society, including marital, familial, and occupational difficulties (Adler et al., 2011; Sayer et al., 2010; Van Til et al., 2013). Although many factors likely contribute to these reintegration problems, among the most widely accepted risk factors are the psychological and physiological sequelae from prior combat experiences (Hoge et al., 2004; Schnurr, Lunney, Bovin, & Marx, 2009). Indeed, posttraumatic stress disorder (PTSD) and mild traumatic brain injury (mTBI) have been labelled the "signature" injuries associated with the conflicts in Afghanistan and Iraq (Operation Enduring Freedom and Operation Iraqi Freedom; OEF/OIF) (Burke, Degeneffe, & Olney, 2009). Impaired functioning is one of the criteria necessary for PTSD diagnosis per the *Diagnostic and Statistical Manual of Mental Disorders* (*DSM*; American Psychiatric Association, 2013), and a robust literature links PTSD with impaired functioning in academic, occupational, and social domains (for review, see Rodriguez, Holowka, & Marx, 2012). Similarly, history of mTBI has been identified as a risk factor for impairment in social functioning, particularly among those who display persistent affective and cognitive symptoms as part of a "postconcussion syndrome" (PCS; Lalonde, Bernier, Beaudoin, Gravel, & Beauchamp, 2016; McCrea, 2008; McMahon et al., 2014; Sayer, 2012; Temkin, Corrigan, Dikmen, & Machamer, 2009). Quality of life and subjective well-being may also be compromised in a subsample of individuals with a history of mTBI (Dijkers, 2004), with greater impairment shown in individuals who have experienced multiple

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mTBIs (Bryan, 2013; Caron, Bloom, Johnston, & Sabiston, 2013; Kuehl, Snyder, Erickson, & McLeod, 2010). In order to facilitate reintegration and increase the quality of life in returning veterans, it is critical to understand the mechanisms by which trauma-related disorders, such as PTSD and the aftereffects of mTBI, lead to functional impairment.

One factor complicating this pursuit is the co-occurrence of PTSD and mTBI in the military population (Bryant, 2011), which can make it difficult for clinicians to identify the underlying causes for impaired social and occupational functioning. There is considerable overlap between PTSD symptoms and chronic symptoms expressed in some cases of mTBI (Bryant, 2011; Stein & McAllister, 2009). Both conditions are characterized by increases in affective symptoms, such as dysphoria, anxiety, numbing, and irritability (Elhai et al., 2011; King, Leskin, King, & Weathers, 1998; Schneiderman, Braver, & Kang, 2008; Simms, Watson, & Doebbelling, 2002; Stein & McAllister, 2009), that map onto the internalizing dimension of psychopathology (Krueger, 1999; Watson, 2005). The internalizing dimension, characterized by symptoms such as negative affectivity and distress that are generally directed inward, cuts across diagnostic categories and is commonly observed in mood and anxiety disorders (Krueger, 1999; Watson, 2005). Internalizing symptoms have been shown to lead to a constant, linear decline in functioning (Kessler, Zhao, Blazer, & Swartz, 1997; Markon, 2010), which includes functional deficits in individuals with internalizing symptoms below diagnostic thresholds (Gotlib, Lewinsohn, & Seeley, 1995; Judd, Paulus, Wells, & Rapaport, 1996; Sherbourne et al., 1994).

In addition to shared internalizing symptoms, both PTSD and mTBI can lead to disruptions in cognitive processes, although there is great heterogeneity in the prevalence, severity, and duration of cognitive symptoms following physiological and psychological trauma (Dikmen, Machamer, Temkin, Grant, & Adams, 2009; Konrad et al., 2011; Nelson et al., 2010; Schuitevoerder et al., 2013). The relationship between cognitive trauma sequelae and social functioning is less well-established. Although neuropsychological outcomes are generally poor predictors of future functioning (Lezak, Howieson, & Loring, 2004; Sbordone, 2001), there is evidence to suggest that certain subpopulations characterized by substantial cognitive impairment do show declines in functioning and quality of life that correlate with the extent of cognitive impairment. These include individuals diagnosed with such conditions as schizophrenia (Laes & Sponheim, 2006; Liddle, 2000), neurodegenerative dementia (Loewenstein, Rubert, Arguelles, & Duara, 1995; Reger et al., 2004), multiple sclerosis (Chiaravalloti & DeLuca, 2008), and attention deficit hyperactivity disorder (Antshel et al., 2010). For individuals who have experienced TBI, the consistency of the relationship between cognition and functioning varies based on injury severity (Sigurdardottir, Andelic, Roe, & Schanke, 2009). In moderate-to-severe TBI, robust evidence supports the relationship between early neuropsychological deficits and later functional outcomes (Sherer, Novack, et al., 2002; Sherer, Sander et al., 2002), with additional evidence supporting the relationship between cognitive status and functional outcomes assessed simultaneously (Atchison et al., 2004; Temkin, Machamer, & Dikmen, 2003). However, in mTBI cases, the impact of cognition on functioning is less clear. Although some studies show a correlation between cognitive performance and functional outcomes in mTBI samples (Hanlon, Demery, Martinovich, & Kelly, 1999), others have found no such relationship (Sigurdardottir et al., 2009; Temkin et al., 2009). Still other mTBI studies have shown that the relationship between functional impairment and subjective or objective indices of cognition is ultimately better explained by internalizing symptoms (Polusny et al., 2011; Ponsford et al., 2000).

Taken together, these findings suggest that there are multiple mechanisms that may result in functional difficulties in returning veterans. However, the relative impact of these various mechanisms is largely unknown, owing to the sparse research that jointly assesses the co-occurrence of trauma-related affective symptoms, cognitive impairment, and mTBI characteristics in combat-exposed veterans. To better understand primary contributors to postdeployment civilian reintegration difficulties of recent veterans, the present study used structural equation modeling (SEM) to model the relationship between dimensional indices of these three domains in a sample of OEF/OIF veterans. SEM allows for the measuring of direct and indirect effects of trauma-related symptomatology on social functioning, and modeling these symptoms dimensionally allows for prediction of functional outcomes across the full range of observed outcomes, rather than just those that meet *DSM* criteria for a psychiatric condition. The ultimate goal of this approach is to better understand what symptoms or combination of symptoms most contribute to functional impairments that interfere with reintegration. Identifying these putative mechanisms may be useful to clinicians by prioritizing targets of intervention, particularly in patients with comorbid histories of PTSD and mTBI (Sayer et al., 2009).

Method

Participants

The sample consisted of 295 U.S. military veterans (94% male; mean age = 32.6, *SD* = 1.84, range = 22–60) who completed study procedures at the Minneapolis VA Health Care System (MVAHCS). All participants were deployed to combat zones as part of OEF/OIF. The racial distribution of the sample was as follows: 72% Caucasian, 3% African American, 3% Native American, 2% Hispanic/Latino, and 20% Mixed Race/Other. To maximize the representation of mTBI in the sample, participants who self-reported either impact or blast mTBI (based on positive response to the VA TBI screening tool; Donnelly et al., 2011) were specifically recruited along with a more general sample of Minnesota National Guard soldiers, veterans from the MVAHCS patient rosters, and veterans referred by word of mouth from other participants or service providers. Participants were excluded due to history of moderate or severe TBI (defined as loss of consciousness [LOC] longer than 30 minutes or posttraumatic amnesia [PTA] longer than 24 hours), non-TBI neurological conditions, current psychotic symptoms, substance abuse or dependence other than alcohol, unstable medical conditions that could affect brain function (e.g. diabetes), and significant imminent risk of suicidal or homicidal behavior. Information about participants' income or socioeconomic status was not collected. All study procedures were approved by the MVAHCS institutional review board. All participants completed a comprehensive battery of assessments (described below) administered by doctoral students and dedicated research staff under the supervision of the principal investigator (S.R.S.) and following completion of all measure-specific training protocols implemented by doctoral-level clinical researchers.

Measures

Assessment of functional impairment

Social Adjustment Scale–Self-Report (SAS-SR): Short. The SAS-SR: Short is a 24-item self-report assessment that measures role performance in six domains of functioning (Gameroff, Wickramaratne, & Weissman, 2012). These domains include (as applicable) work role, social and leisure activities, extended family, primary relationship, parental role, and role within the family unit. Questions are rated on a 5-point scale and are designed to assess expressive and instrumental performance over the prior two weeks. Overall mean and means within domain are calculated, with higher scores denoting greater impairment. The SAS-SR: Short has shown strong intercorrelation with the full SAS-SR across all domains (all *r*s between 0.81 and 0.98) and has shown significant intercorrelations with quality-of-life indices such as the mental component of the Short Form 36 Health Survey (SF-36; $r = -0.61$) (Gameroff et al., 2012).

Clinical assessments

Clinician Administered PTSD Scale for DSM-IV (CAPS). The CAPS is a 30-item, clinician-administered scale designed to provide both categorical PTSD diagnostic determinations as well as continuous symptom frequency and intensity measures (Blake et al., 1995). The scale begins with the identification of an index trauma, using criteria laid out in the *DSM-IV* (American Psychiatric Association, 2000). Of the 30 items, 17 correspond to the four factor model of PTSD proposed by Simms and colleagues (2002). These factors are intrusion symptoms (CAPS items B1–B5), avoidance symptoms (C1–C2), dysphoria symptoms (C3–D3), and hyperarousal symptoms (D4–D5). These items were scored separately for frequency and intensity using a 5-point scale (0–4). Symptom severity for each item was calculated by summing the frequency and intensity scores.

Structured Clinical Interview for DSM-IV-TR (SCID). Depression was assessed using the mood module of the SCID, a structured diagnostic examination designed to identify Axis I disorders in a research patient population (First, Spitzer, Gibbon, & Williams, 2002). Items on the SCID are rated on a 3-point scale, with 3 reflecting criteria met, 2 reflecting subthreshold symptoms, and 1 reflecting no symptoms. For the present study, cumulative score on the first two questions of the mood module, assessing Criteria 1 and 2 of current Major Depressive Episode (depressed mood most of the day nearly every day and decreased interest or pleasure in most activities), were used to measure current depression symptoms.

Multidimensional Personality Questionnaire–Brief Form (MPQ-BF). The MPQ-BF is a 155-item test designed to assess 4 higher and 11 lower order personality traits (Patrick, Curtin, & Tellegen, 2002). For the present study, the higher order Negative Emotional Temperament dimension (MPQ-NEM) and lower order Well-Being trait (MPQ-WB) were used to operationalize trait internalization. Higher MPQ-NEM and lower MPQ-WB scores reflect greater symptomatology. Although trait measures such as these are not theorized to change as a function of trauma, research has shown that personality factors can impact the clinical response to trauma (e.g. Arbisi, Polusny, Erbes, Thuras, & Reddy, 2011; Bramsen, Dirkzwager, & van der Ploeg, 2000), thus influencing the level of internalization at the time of the assessment.

Assessment of mTBI

Minnesota Blast Exposure Screening Tool (MN-BEST). The MN-BEST (Nelson et al., 2011) is a clinician-administered TBI screening instrument designed to obtain comprehensive information on the acute impact of an individual's three most significant concussive impact-only events and the three most significant concussive blast-related events. Each self-reported mTBI is classified on the basis of acute-stage injury parameters outlined by the American Congress of Rehabilitation Medicine (ACRM; Kay, Harrington, & Adams, 1993), including LOC no more than 30 minutes in duration and PTA no more than 24 hours in duration. The measure also collects characteristics of the trauma, including the approximate time since injury, estimated proximity to blast, and presence of mediating factors (e.g., protective equipment), as well as characteristics of the clinical outcome, including LOC, PTA, and neurological symptoms. MN-BEST results were reviewed by neuropsychologists trained and experienced in the clinical presentation of TBI and evaluated as to whether the injury plausibly meets the minimal biomechanical threshold of concussion (McCrea, 2008). The reviewers assigned composite mTBI symptom severity ratings to incidents rated as "likely" or "more likely than not" to have resulted in concussion based on a modified version of the scoring scheme proposed by Ruff and Richardson (1999). Reviewers assigned a 0 (no brain injury) to 4 (severe concussion symptoms) score for each concussive event and totaled the scores for the three worst impact-only and three worst blast-related incidents to determine separate impact mTBI symptom severity and blast mTBI symptom severity indices. For specific MN-BEST scoring procedures, see Nelson et al. (2011).

Cognitive assessment. Of the 295 total participants, 259 completed a cognitive battery composed of measures representing cognitive performance across domains. Due to the variety and heterogeneity of measures included in the battery, an exploratory factor analysis (EFA) was applied to identify the underlying factor structure of cognitive variables. Based on the results of the EFA (described below), the following measures, a subset of the overall battery, were selected for use in subsequent models.[1] The California Verbal Learning Test–Second Edition (CVLT-II) was included to measure learning and memory and to assess both quantitative (e.g., recall capacity) and qualitative (e.g., memorization strategy) aspects of cognition (Delis, Kramer, Kaplan, & Ober, 2000). A confirmatory factor analysis (CFA) of CVLT-II outcomes in a general sample (Donders, 2008) and a sample of individuals with histories of TBI (DeJong & Donders, 2009) identified four factors, and composite scores reflecting performance on the Attention Span and Delayed Recall factors were included in subsequent models. The Trail Making Test (TMT) was included to measure visual attention and cognitive processing speed (TMT-A) as well as task switching and executive functioning (TMT-B; Bowie & Harvey, 2006). Time taken to complete each part was used in subsequent analyses. Two subtests from the Wechsler Adult Intelligence Scale–Third Edition (WAIS-III) were also used. Specifically, the Digit Span subtest was used to measure attention and working memory, and the Block Design subtest was used to assess visual spatial processing and visual motor construction (Wechsler, 1997). Age-standardized scaled scores for each subtest were used in subsequent analyses.

Of the 259 participants who completed cognitive testing, 117 also completed three additional tasks. The Stroop Color and Word Test (Stroop test) was used to measure executive function and processing speed, with a particular focus on selective attention (Golden & Freshwater, 1978). The standardized score on the color-word list was used in subsequent analyses. The Controlled Oral Word Association Test (COWAT) was included to measure verbal fluency (Benton & Hamsher, 1976; Gladsjo et al., 1999). The age-standardized score for total words generated across all three lists (F, A, and S) was used in subsequent analyses. Finally, delayed recall accuracy from the Rey-Osterrieth Complex Figure test (ROCF) was used to measure visuospatial skills, memory, attention, and planning (Shin, Park, Park, Seol, & Kwon, 2006). Accuracy of the recalled figure, scored using standardized criteria (Osterrieth, 1944), was used in subsequent analyses.

Effort measures. Four separate tasks were used to measure participant effort/engagement during neuropsychological testing. Any participant whose performance failed to meet effort thresholds for more than one of the four tasks was excluded from subsequent analyses. These tasks, along with the thresholds used to identify poor effort, are as follows. For the Victoria Symptom Validity Test (VSVT), a threshold of 43 or fewer correct answers was used based on a military sample comprised of primarily mTBI patients (Jones, 2013). For the WAIS-III Digit Span subtest, a scaled score threshold of 5 or lower was used (Babikian, Boone, Lu, & Arnold, 2006; DeJong & Donders, 2009; Young, Sawyer, Roper, & Baughman, 2012). For the embedded CVLT-II Forced Choice measure (CVLT-FC), a score of 14 or lower has been shown to identify poor effort in clinical, nonclinical, forensic, and TBI samples (Moore & Donders, 2009; Root, Robbins, Chang, & van Gorp, 2006). For the TMT-A task, a completion time of 48 seconds or higher was used, based on a sample of individuals with mTBI (Iverson, Lange, Green, & Franzen, 2002).

Of the 259 participants who completed the cognitive battery, 9 were excluded based on the criteria of failing more than one effort measure. Of those 9, 7 failed two effort measures and 2 failed three effort measures. For individual effort measures, 35 (13.51%) failed the VSVT, 18 (6.95%) failed the CVLT-FC, 5 (1.93%) failed WAIS-IV Digit Span, and 5 (1.93%) failed TMT-A.

Analytic approach. Analyses for this project were conducted in phases. Given the large amount of measures and variables under study, we used structural modeling analyses to reduce the number of constructs to a reasonable number to explore their relationships in SEM. In the first phase, measurement models were established using EFA and CFAs. Symptomatology and functional impairment variables were modeled together in the first measurement model. The cognitive variables were analyzed separately in a second measurement model. Next,

Table 1. Descriptive Statistics for Measurements Included in Factor Analysis and SEM Models

Clinical assessments				Cognitive assessments			
Measure	Mean	*SD*	Observed range	Measure	Mean	*SD*	Observed range
CAPS intrusions	12.35	7.81	0 to 34	CVLT: Attention span	−1.17	2.06	−7.5 to 4.5
CAPS avoidance	7.39	3.81	0 to 16	CVLT: Learning efficiency	0.51	2.66	−8 to 8
CAPS dysphoria	19.64	12.36	0 to 34	CVLT: Delayed recall	−0.72	4.51	−18 to 9
CAPS hyperarousal	7.57	3.32	0 to 38	CVLT: Inaccurate recall	0.18	1.72	−2 to 6
MDE Criteria 1 and 2	3.07	1.40	2 to 6	TMT-A (t)	50.20	10.33	9 to 84
MPQ-NEM	7.04	3.27	1.13 to 16.25	TMT-B (t)	49.96	9.97	11 to 78
MPQ-WB	7.08	3.43	1 to 12	WAIS-III: Information (SS)	11.70	2.11	6 to 16
				WAIS-III: Digit span (SS)	9.93	2.50	6 to 17
				WAIS-III: Coding (SS)	9.85	2.50	3 to 16
				WAIS-III: Block design (SS)	12.27	2.79	7 to 19
				WTAR Premorbid FSIQ	103.20	8.52	73 to 123
				Stroop Color-Word (z)	−0.17	0.89	−2.31 to 1.76
				COWAT (z)	−0.48	1.01	−3 to 1.76
				ROCF: Delayed recall (z)	−0.49	1.20	−3 to 1.65
mTBI assessments				**Functioning assessments**			
Measure	Mean	*SD*	Observed range	Measure	Mean	*SD*	Observed range
Impact mTBI symptoms	1.76	2.41	0 to 21	Work role	1.80	1.08	1 to 6
Blast mTBI symptoms	1.28	2.02	0 to 17	Social/leisure activities	2.19	0.69	1 to 4.33
				Extended family	2.17	0.88	1 to 4.67
				Primary relationship	2.18	0.85	1 to 4.67
				Parental role	1.81	0.63	1 to 4
				Family role	2.00	0.85	1 to 5

Note: Functional measures are reported only for participants who endorsed fulfilling the reported role (e.g., parental role only completed by participants with children). For standardized cognitive assessments, score type is included in parentheses. SS = scaled score; t = *t* score; z = *z* score.

SEM was used to examine relationships between symptomatology, functional impairment, cognitive, and mTBI symptom scores. Factor scores from the best-fitting cognitive model were included in the SEM alongside observed severity of impact and blast mTBI events. Analyses were conducted in Mplus (version 7.1; Muthén & Muthén, 2012). The full information maximum likelihood method was used for all measurement models, which results in the exclusion of any observations containing missing data. The following criteria were used for addressing model fit of measurement models and the SEM: lower values of the Bayesian information criterion (BIC), a root mean square error of approximation (RMSEA) and standardized root mean residual (SRMR) < .08, and a comparative fit index (CFI) greater than .95 (Byrne, 2013). The extent that each criterion is used to identify the best-fitting model will be reviewed in the Results section below.

Results

Assessment outcomes

Based on the MN-BEST assessment, 197 participants (66.8%) endorsed at least one mTBI, with 120 participants (40.7%) reporting at least one blast-related mTBI and 146 participants (49.5%) reporting at least one impact-related mTBI. Based on the CAPS interview, 98 participants (33.2%) met criteria for current or lifetime history of PTSD. Although this percentage is higher than the expected prevalence of PTSD among combat veterans (Thomas et al., 2010), it is not unexpected considering that many participants were recruited based on their endorsement of mTBI and connection with MVAHCS services. For a complete list of summary statistics across the entire sample, see Table 1. Summary statistics are presented for all participants who completed each measure.

Latent variable structure

Clinical variables. The symptomatology (i.e., PTSD symptoms, depression), personality (i.e., MPQ-NEM, MPQ-WB), and functional impairment (i.e., SAS-SR cluster scores of functioning in primary relationship, parenting, family, social, extended family, and work domains) variables were submitted to EFA. The results indicated testing four models in a CFA framework. CFA-1 loaded all variables on a single dimension (one-factor model), and CFA-2 loaded PTSD symptoms on one factor and depression, personality, and functional impairment loading variables on a second factor (two-factor model). Given our interest in identifying a functioning construct that would facilitate interpretation of subsequent SEM models, CFA-3 tested a model in which PTSD symptoms, depression, and personality variables were specified to load on an overarching distress or internalizing factor, and SAS-SR variables were specified to load on a separate functional impairment construct. CFA-4 tested a higher order model in which a second order internalizing factor, marked by PTSD symptoms and a distress factor indicated by depression, MPQ-NEM, and MPQ-WB, was specified to correlate with the functional impairment factor marked by social functioning indicators. Absolute fits for CFA-2–4 were adequate or better (see Table 2). Although CFA-2 had lower BIC and higher CFI, ultimately CFA-4 was selected for subsequent analysis, since it allowed for isolating functional impairment (which CFA-2 did not) and it had better fit than CFA-3 across all indices (BIC, RMSEA, CFI, and SRMR). Parameter estimates for CFA-4 are presented in Figure 1a.

Cognitive variables. A second set of analyses was conducted to explore the latent structure of cognitive measures. EFA suggested testing four one- to three-factor models in CFA, and fit indices for all cognitive CFAs are presented in Table 2. CFA-5 included all scales loading on a single dimension (one-factor). CFA-6 included the two CVLT variables (attention span and delayed recall) on the first factor, and TMT-B, TMT-A, WAIS-III digit span, WAIS-III block design, ROCF, Stroop test, and COWAT loading on a second factor (two-factor). CFA-7 included the two CVLT variables loading on one factor; TMT-B, TMT-A, WAIS-III digit span, and WAIS-III block design loading on a second factor; and ROCF, Stroop test, and COWAT loading on a third factor (three-factor). Finally, we also tested a hierarchical model, CFA-8, which included a general factor accounting for appreciable variance in all indicators and residual factors independently varying from the general dimension. CFA-8 was informed by exploratory bifactor modeling analyses and included two residual cognitive factors (RCF): one specified by CVLT attention span and delayed recall factors (RCF1), and another by Stroop test, COWAT, and ROCF (RCF2). This model fit best, with satisfactory fit measured using RMSEA (.031), CFI (.980), and SRMR (.039). Factor scores from CFA-8 were included in the SEM, and parameter estimates for CFA-8 are presented in Figure 1b.

SEM

The SEM linking factors derived in measurement modeling analyses and observed mTBI symptom severity scores are presented in Figure 2. Fit was adequate for this model as indicated by the RMSEA and SRMR, with a marginally acceptable CFI (–2 log likelihood [*LL*] = –8,259, k = 99, BIC = 17,053, RMSEA = .053, CFI = .830, SRMR = .069). Notably, the correlation between the latent internalizing and functional impairment factors was $r = .72$. Paths were

Table 2. Measurement and Factor Analysis Model Fit Statistics

Model	–2LL	k	BIC	RMSEA	CFI	SRMR
Clinical variables (*N* = 295)						
CFA-1: 1-factor	–10,771	52	21,838	.148	.000	.306
CFA-2: 2-factor	–9,711	79	19,870	.048	.904	.058
CFA-3: 2-factor	–9,761	79	19,971	.058	.859	.066
CFA-4: 2-factor	–9,730	84	19,937	.053	.884	.064
Cognitive variables (*N* = 246)						
CFA-5: 1-factor	–4,290	27	8,728	.136	.522	.086
CFA-6: 2-factor	–4,253	28	8,660	.079	.844	.064
CFA-7: 3-factor	–4,239	30	8,644	.058	.923	.049
CFA-8: Bifactor	–4,233	32	8,645	.031	.980	.039

Note: BIC = Bayesian information criterion; CFI = comparative fit index; k = number of free parameters; LL = loglikelihood; RMSEA = root mean square error of approximation; SRMR = standardized root mean square residual.

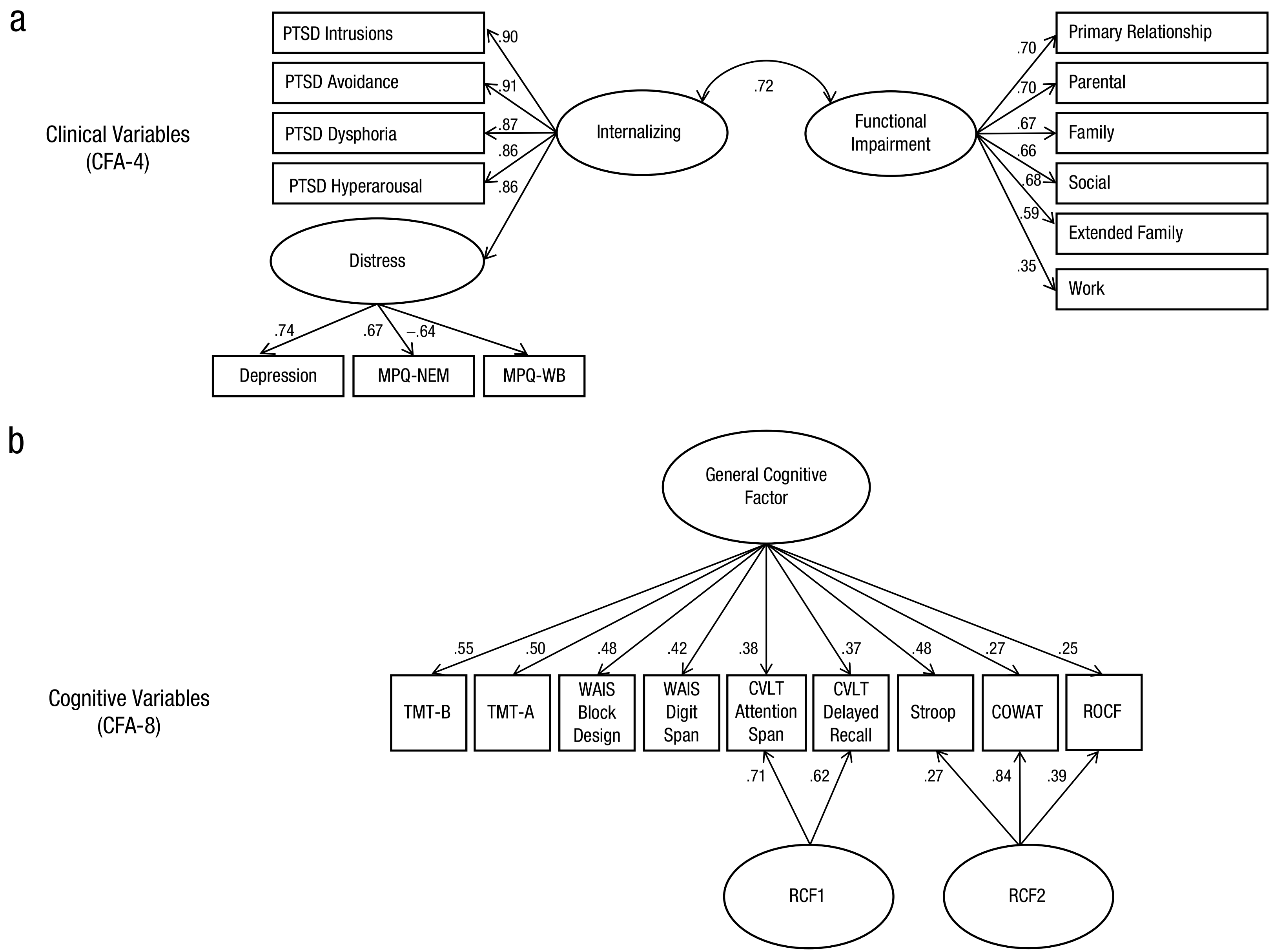

Fig. 1. Measurement model parameter estimates. Shown are the latent structures for the selected clinical and cognitive variables (CFA-4 and CFA-8, respectively). (a) The latent structure of both the internalizing and functional impairment structures indicates strong loading of the observed clinical variables on the internalizing factor and SAS-SR variables on the functional impairment factor (N = 295). (b) The best fitting hierarchical (bifactor) model of cognitive functioning shows that each indicator is saturated by an overarching general cognitive factor, and two residual cognitive factors (RCF1 and RCF2) vary independently from the general factor and from one another (N = 246). COWAT = Controlled Oral Word Association Test; CVLT = California Verbal Learning Test; MPQ = Multidimensional Personality Questionnaire; NEM = Negative Emotional Temperament; PTSD = Posttraumatic Stress Disorder; ROCF = Rey-Osterrieth Complex Figure; SAS-SR = Social Adjustment Scale–Self-Report; TMT-A = Trail Making Test Part A; TMT-B = Trail Making Test Part B; WAIS = Wechsler Adult Intelligence Scale; WB = Well-Being.

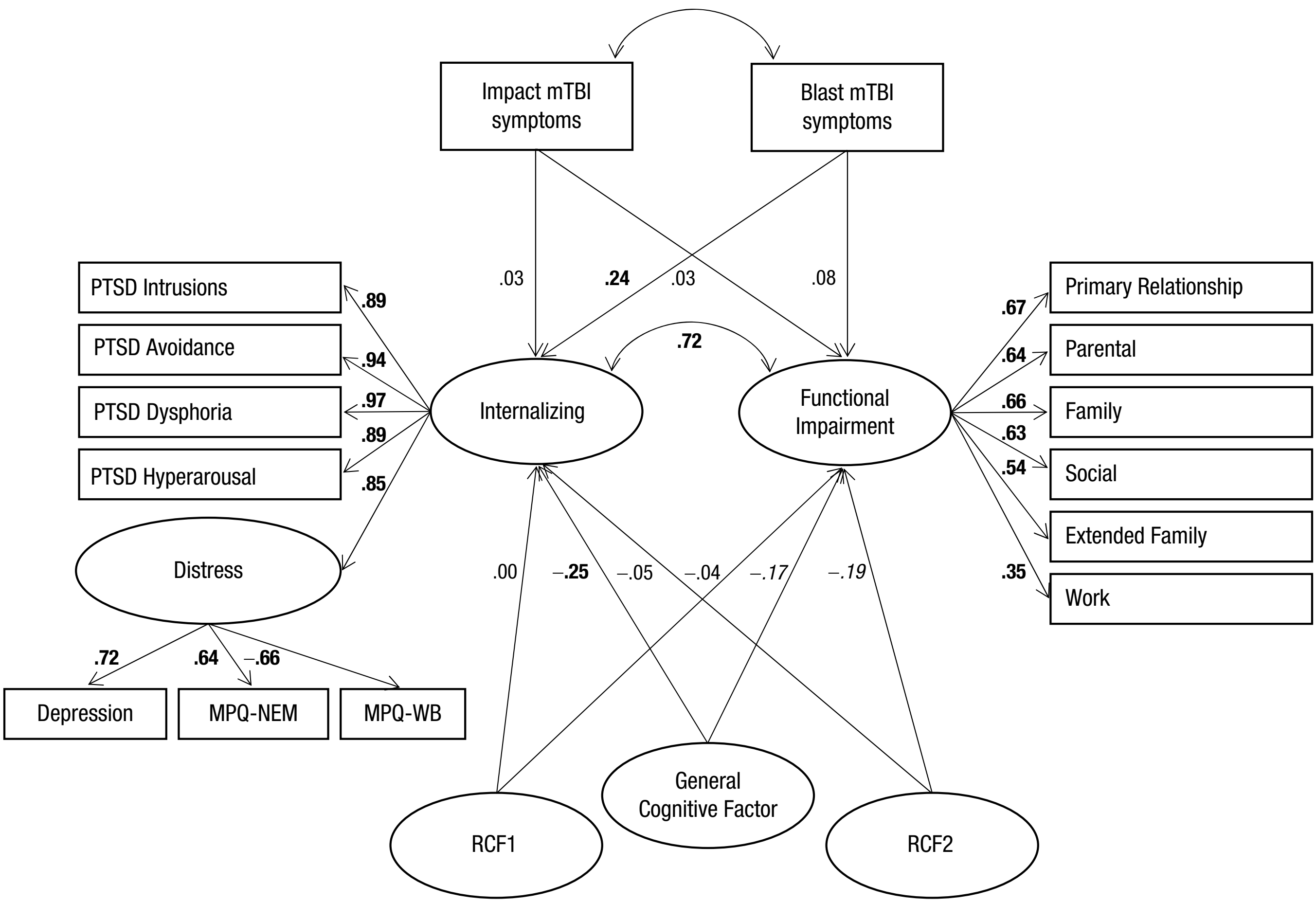

Fig. 2. SEM depicting relationships between internalizing and functional impairment factors with mTBI symptoms and cognitive factors regressed upon them ($N = 225$). Note all paths in italics are significant at $p < .05$, and paths in bold are significant at $p < .001$. Shown is the series of relationships between all latent factors along with the two observed mTBI symptom severity scores. Paths between mTBI factors and cognitive measures were nonsignificant and therefore were excluded to enhance model fit. MPQ = Multidimensional Personality Questionnaire; NEM = Negative Emotional Temperament; PTSD = Posttraumatic Stress Disorder; RCF = Residual Cognitive Factor; WB = Well-Being.

not significant between the functional impairment factor and either impact- or blast-related mTBI symptoms. Higher blast mTBI symptom severity was related to increased internalizing ($\beta = .24$, $p < .001$) and indirectly related to greater functional impairment via internalizing ($\beta = .17$, $p = .02$). Impact mTBI symptom severity was related to neither internalizing nor functional impairment. In terms of cognitive functioning, lower general cognitive functioning was associated with increased internalizing ($\beta = –.25$, $p < .001$). There was a modest but significant association between functional impairment and both the general cognitive factor ($\beta = –.17$, $p = .02$) and RCF2 ($\beta = –.19$, $p = .02$), such that poorer cognitive performance was modestly associated with greater functional impairment. Additionally, there was an indirect association between the general cognitive factor and functional impairment via internalizing ($\beta = –.18$, $p = .02$). RCF1 was not significantly correlated with internalizing or functional impairment. Paths connecting the mTBI symptom indices and the cognitive factors were nonsignificant (all $p > .05$) and were ultimately excluded from the presented SEM for the purposes of model fit.

Discussion

The results of the SEM analysis shed considerable light on the factors that contribute, directly and indirectly, to postdeployment functional impairment in trauma-exposed veterans. Specifically, the model reinforces that increased internalization symptoms are strongly associated with greater social and occupational impairment. Importantly, it also underscores that postdeployment functioning is not impacted by a remote history of mTBI, except insofar as those factors are indirectly associated through internalizing symptoms. Due to the cross-sectional design of the present study, it is impossible to determine if the association between internalization and functional impairment is causal. Indeed, the association may well be cyclical, with mood symptoms detracting from social role performance and subsequent impaired social relationships resulting in worsening mood symptoms.

These findings expand on studies that look at the psychological and mTBI sequelae in tandem. Polusny and colleagues noted that history of mTBI did predict poorer psychosocial outcomes but that this relationship disappeared after controlling for concomitant PTSD symptoms (Polusny et al., 2011). Similarly, PTSD was more strongly associated with functioning in a sample of OEF/OIF veterans compared to those with mTBI (Jackson et al., 2016). A limitation of these previous findings is the use of a categorical PTSD diagnosis to differentiate groups. Indeed, subthreshold PTSD (i.e., meeting several but not all *DSM* criteria) is a common sequela to trauma that is also linked to negative clinical and functional outcomes (Cukor, Wyka, Jayasinghe, & Difede, 2010; McLaughlin et al., 2015). By modeling the internalizing dimension continuously, the present analysis can reflect the association between internalization and functioning across the full spectrum of sub- and suprathreshold trauma-related symptomatology.

These findings also support the literature suggesting that acute symptoms attributable to mTBI fail to contribute to long-term functional impairments, except in those cases where postconcussion symptoms persist (Iverson, Zasler, & Lange, 2007; McCrea et al., 2009; McMahon et al., 2014). Although research has linked chronic and repetitive mTBIs to progressive neurological disorders, which can significantly impair functioning (such as chronic traumatic encephalopathy; McKee et al., 2009), the present findings suggest that the functional impact of more acute mTBI symptomatology may be better accounted for by trauma-related psychopathology.

The present study is the first, to our knowledge, to also look at the joint contributions of cognitive performance along with mTBI and psychological symptoms in predicting functional outcomes. This addition is necessary considering that subjective cognitive complaints are commonly observed in combat-exposed veterans and frequently cited by veterans as a factor complicating reintegration (Binder et al., 1999; Persian Gulf Veterans Coordinating Board, 1995). In the present sample, however, the association between general cognitive performance and functioning was modest and was actually slightly less than the indirect association between cognition and functioning mediated by internalization (direct $r = -0.17$, indirect $r = -0.18$). The present model is consistent with research that links post-mTBI cognitive performance to psychological symptoms (Drag, Spencer, Walker, Pangilinan, & Bieliauskas, 2012; Spencer, Drag, Walker, & Bieliauskas, 2010) and also reaffirms the limitations of using cognitive performance alone to predict functional outcomes (Lezak et al., 2004; Sbordone, 2001). In addition, this relationship between general cognition and internalization symptomatology underscores the importance of assessing mood as part of neuropsychological evaluations.

To understand the lack of association between mTBI symptoms and functional impairment, it is important to consider the general trajectory of recovery following concussion. In the majority of mTBI cases, symptoms resolve within days or weeks of the injury, with return to baseline expected within 3 months at the latest (McCrea et al., 2009). A more recent prospective study in a large sports concussion sample demonstrated that recovery patterns may be somewhat more protracted among those whose injuries resulted in any period of LOC or PTA, but prognosis for complete recovery within weeks to months was nevertheless the rule in the great majority of injured athletes (McCrea et al., 2013). A small minority of mTBI cases express difficulties akin to the persistent PCS, which can include symptoms that overlap with internalizing disorders, such as depression, anxiety, irritability, and sleep disturbance (Iverson et al., 2007; McCrea, 2008; Stein & McAllister, 2009). Although multiple neurobiological and psychological factors have been shown to predict the onset and course of PCS (Dischinger, Ryb, Kufera, & Auman, 2009; Morgan et al., 2015; Snell, Macleod, & Anderson, 2016), there is little evidence suggesting that symptoms attributable to mTBI are associated with long-term functional outcomes. Therefore, on the basis of past and present findings, it is reasonable to expect that the impact of mTBI symptoms on long-term functioning is predominantly attributable to the resulting internalizing symptoms associated with trauma-related psychopathology.

Limitations of the present study include its cross-sectional design, which makes it difficult to infer causality from the relationships presented in these models. Because social functioning can vary considerably over time, longitudinal studies with repeated and varied assessments (such as tracking activities of daily living or vocational performance) are necessary to fully appreciate the observed correlations. In addition, the neuropsychological assessment measures used in this study were chosen from a representative, but not comprehensive, subset of the cognitive battery. Although we saw a comparable relationship between cognition and functioning using the full cognitive battery, that does not preclude the possibility that other cognitive measures may provide more utility in predicting functional impairment. Additional studies using a more extensive battery may be necessary to better understand the influence of cognition on functional impairment in OEF/OIF veterans.

Another limitation relates to the exclusive reliance on retrospective self-report to inform mTBI history. As is typical of the vast majority of published OEF/OIF outcome studies, external information (e.g., acute-stage medical records; eyewitness accounts) corroborating combat-related mTBI were not presently available for review. In consideration of the extended duration of time that transpired between incident events and research assessments completed in the current study, it is understandable that veterans would experience difficulty representing acute-stage injury characteristics (e.g., duration of LOC and PTA) with precision. Research also suggests that posttraumatic stress and other unresolved psychological difficulties that persist during the postdeployment phase significantly impact the stability of retrospective endorsement of mTBI (Nelson et al., 2015). The degree to which symptoms of depression and PTSD resulted in inaccuracies in self-reported mTBI in the current sample remains unclear.

Despite these limitations, the present findings may help guide clinicians as they seek to optimize treatment outcomes, particularly given the high co-occurrence of PTSD and symptoms akin to PCS (Schneiderman et al., 2008; Stein & McAllister, 2009). The latent internalizing factor, composed of PTSD, depression, and personality characteristics, is by far the strongest correlate of social functioning, easily exceeding the contributions of both acute mTBI symptoms and cognitive performance. Importantly, the underlying cause of internalization may not always stem directly from combat experiences (indeed, internalizing symptoms such as low mood, irritability, or social withdrawal can be caused by varied factors, such as PTSD, PCS, or trait characteristics). However, the current model suggests that the presence of these symptoms, regardless of their source, is enough to put an individual at significant risk of functional impairment. Clinical interventions targeting either internalizing symptoms or social functioning could lead to global improvements in both domains. Several well-established forms of psychotherapy, including cognitive behavioral therapy and interpersonal therapy, have shown efficacy in decreasing internalizing symptoms (Butler, Chapman, Forman, & Beck, 2006; van Hees, Rotter, Ellermann, & Evers, 2013) and improving social functioning outcomes (de Mello, de Jesus Mari, Bacaltchuk, Verdeli, & Neugebauer, 2004; A. I. Scott, Rodger, Stocks, & Shering, 1992; Scott et al., 2000). For individuals whose internalizing symptoms are driven by trauma-related experiences (i.e., those that might meet criteria for PTSD), prolonged exposure and cognitive processing therapy are considered the "gold standard" technique for improving symptoms and social functioning (Rauch, Eftekhari, & Ruzek, 2012). The present results support the prioritizing of internalization and social symptom interventions over interventions that target the cognitive symptoms of trauma-exposed patients.

Author Contributions

S. R. Sponheim developed the study concept with assistance from M. A. Polusny and N. W. Nelson. Study execution was directed by S. R. Sponheim. Principle analyses were conducted by M. D. Kramer with assistance from S. G. Disner, A. J. Lipinski, and J. M. Christensen. S. G. Disner and M. D. Kramer interpreted the outcomes, with support and guidance from S. R. Sponheim and N. W. Nelson. S. G. Disner drafted the manuscript, with assistance from M. D. Kramer and J. M. Christensen, and under the supervision of S. R. Sponheim. All authors approved the final version of the paper for submission. This material is the result of work supported with resources and the use of facilities at the MVAHCS. The contents do not represent the views of the U.S. Department of Veterans Affairs or the United States Government.

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The authors declared that they had no conflicts of interest with respect to their authorship or the publication of this article.

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Note

1. A comparable version of the final SEM model using results from the full cognitive battery was nearly identical to the presented analyses but with markedly poorer model fit attributable to the heterogeneity of neuropsychological assessments.

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