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Post-Traumatic Stress Disorder and Blast Exposure in Active-Duty Military Service Members

Angela Sekely [1], Hinza B. Malik [1], Kayla B. Miller [2], Yishi Wang [1] and Antonio E. Puente [1,*]

[1] Department of Psychology, University of North Carolina Wilmington, Wilmington, NC 28403, USA; angela.sekely@uhn.ca (A.S.); hinzabmalik@gmail.com (H.B.M.); wangy@uncw.edu (Y.W.)
[2] Florida Institute of Technology, Melbourne, FL 32901, USA; millerkayla77@gmail.com
* Correspondence: puente@uncw.edu

Abstract: Objective: Active-duty military personnel in the current wars have experienced unique stressors that deviate from standard PTSD assessment and diagnosis. This situation calls for a refinement of military-related PTSD assessment. To this end, this study assessed the utility of the Trauma Symptom Inventory (TSI) in diagnosing PTSD among active-duty military personnel. The past literature has validated the TSI using populations with a small sample size. Hence, this study aimed to fill the gap by using a large sample size of 670 military members to examine whether the TSI is useful for military populations. Setting: Participants were referred to Carolina Psychological Health Services, in Jacksonville, North Carolina by military neurologists and other qualified medical officers from the Naval Hospital in Camp Lejeune, a military base located in Jacksonville, NC, for neuropsychological evaluation due to reported cognitive deficits related to military deployment (i.e., head injury due to exposure to blast injuries). Participants: Based on clinical diagnosis, comprehensive neuropsychological testing, and self-reported data, personnel were classified into four groups: blast exposure (n = 157), PTSD diagnosis (n = 90), both blast exposure and PTSD (n = 283), and neither blast exposure nor PTSD (n = 140), which helps provide a comprehensive picture of the utility of the TSI. Results: The TSI's 10 clinical scales could distinguish between all groups. Discriminant function analysis showed that an optimally weighted combination of scales correctly predicted 66.67% of PTSD-positive cases and 35.11% of PTSD-negative cases. Conclusion: These findings provide support for the use of the TSI in the assessment of PTSD in active-duty military personnel. Due to the release of TSI-2, there is a need to replicate this data. However, the validity data has indicated a high concordance between the TSI and TSI-2, bolstering confidence in the current findings of the study.

Keywords: Trauma Symptom Inventory; military; trauma; PTSD; blast injury

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1. Introduction

The rate of post-traumatic stress disorder (PTSD) is slightly higher among military personnel, such that the lifetime prevalence of PTSD in veterans is 9.4%. In contrast, in civilians it is 6% [1,2]. Rates vary by service era, with the highest prevalence among those returning from current wars in Iraq and Afghanistan [3]. Military personnel are often exposed to a broader range of traumatic events, including the sudden death of a loved one, natural disasters, sexual assault, and combat exposure, elevating the risk of PTSD among military personnel compared with civilians. In addition, clinical presentations may differ among civilian and military populations, with military populations demonstrating higher rates of hypervigilance and compulsive behaviors [4]. Symptom presentation may vary due to the context of the event (i.e., military personnel witnessing the death of a loved one in a war zone relative to civilians witnessing the death of a loved one outside of a war zone) [5]. Further elucidation of military trauma is necessitated by the increased PTSD rates in veterans returning from Operations Iraqi Freedom (OIF) in Iraq and Enduring Freedom

(OEF) in Afghanistan [3,6], as well as the apparent differences in trauma between military and non-military populations.

In addition to PTSD, combat exposure significantly increases the risk for mild traumatic brain injury (mTBI) [7–9]. Approximately 12–22% of veterans from Iraq and Afghanistan have sustained TBI, with the majority (about 80%) of cases being mild in severity [6,8,10], US Department of Defense, 2018. It has been estimated that PTSD occurs in approximately 40% of service members with mTBI exposure [11]. A meta-analysis conducted by Fulton et al. [12] reported that 20–26% of individuals are returning from these wars with PTSD. Both MTBI and PTSD can result in psychosocial and functional impairment [13,14].

Despite the growth in the mTBI and PTSD literature, limited research exists with active military personnel. The most widely studied group has been those who served in Vietnam [15] and not in more recent wars. The US wars in Iraq and Afghanistan are unique for a variety of reasons. Personnel survived combat injuries at higher rates than in previous wars due to advancing military technology. They also reported higher levels of lifetime trauma and combat exposure severity relative to other war eras [3]. Sociodemographic characteristics also reflect a shift in the demographic composition of military personnel, with the wars in Iraq and Afghanistan including increasingly more women, racial/ethnic minorities, and individuals from disadvantaged socioeconomic backgrounds [16,17]. In addition, personnel were deployed for multiple tours of duty that were longer in duration with shorter intervals between deployments, and the average number of traumatic events experienced was more significant, escalating the probability of developing mental health problems [3,18–21].

Furthermore, the US service members involved in the Iraq and Afghanistan wars have experienced traditional combat firefights and the chronic threat of roadside bombs and improvised explosive devices (IEDs) [22]. These blasts often result in polytrauma, with co-occurring physical, cognitive, and/or psychological sequelae, which makes military trauma unique [23,24]. A study conducted by [6] estimated that 90% of service members returning from the wars in Iraq and Afghanistan reported being shot at or seeing dead bodies and/or human remains, and over 80% of these service members reported knowing someone who was seriously injured or killed, consistent with PTSD diagnostic criterion A. Moreover, almost 15% of soldiers have reported an injury during deployment that resulted in a loss of consciousness or altered mental status, consistent with the TBI diagnostic criterion. These characteristics of the current wars may partially explain the significant increase in PTSD incidence rates following the initiation of the wars in Iraq and Afghanistan [25,26].

However, given the high rates of comorbid disorders among service members, PTSD can be particularly challenging to understand and diagnose [27–29]. Symptom overlap between TBI and PTSD, including insomnia, irritability, and difficulty with concentration, convolutes clinical presentation, making it challenging to determine the etiology of specific symptoms [22,27]. These unique challenges highlight the importance of furthering the understanding of military-related PTSD assessment and diagnosis.

Towards this end, the current study used a large archival active-duty military personnel dataset in which the Trauma Symptom Inventory (TSI) [30] was administered as part of a neuropsychological evaluation [31]. The TSI has been a popular self-report instrument in the clinical assessment of PTSD since the last decade [32] and was recommended by the Veterans Administration in the late nineties [33]. The battery was developed and utilized from the beginning of February 2008; thus, the TSI was administered instead of TSI-2, the most recent version, which was not published until 2016. Although the TSI-2 addresses additional symptoms related to trauma, such as sexual dysfunction, that are not well-assessed by other trauma measures, the core PTSD scales are highly correlated between original and revised versions [34]. The TSI is a 100-item self-report inventory that assesses acute and chronic traumatic symptomatology. The TSI manual supports scale reliability, convergent, criterion, and discriminant validity for PTSD subscales, yielding 91.1% correct classification of those who did and did not have PTSD [30]. Self-report is often a limitation of assessment, but when compared with a structured interview for PTSD, 86% diagnostic utility in detecting PTSD among a community sample was found in logistic regression and, hence, deemed appropriate for use [35]. The internal consistency was kept for all the TSI clinical scales, excluding the Tension Reduction Behavior scale, and the convergent validity of the clinical scales was supported using the Personality Assessment Inventory, Beck Depression Inventory, Beck Anxiety Inventory, and the Mississippi Combat PTSD scale. Therefore, the TSI has been well-validated and is comparable to several other screening measures with minimal concern about self-report limitations. Several researchers have supported the TSI's utility for assessing veteran populations within and outside the United States [9,36,37]. However, these studies use a relatively smaller sample than the current study, and no studies have investigated the TSI's utility using an active-duty military sample. There is limited literature on PTSD assessment measures that have been validated using military clinical populations that account for the unique duties and experiences of military service members that affect symptomatology. This literature gap is essential to address a more suitable clinical application in a specific population as an effort to advance assessment and diagnostic procedures [38].

Understanding military trauma is important as it differs from civilian trauma, and the overlap with TBI makes diagnosis difficult. Hence, it is essential to use an assessment that is sensitive to the etiology of symptomology presented in veterans returning from Iraq and Afghanistan. The purpose of the current study is to evaluate the TSI's diagnostic accuracy in detailed groups (with blast exposed only, with PTSD only, with blast exposed and PTSD, and neither of them) using a large database of active-duty military personnel. Specifically, the reliability estimates of the TSI's three validity and ten clinical scales were examined. It was hypothesized that the TSI's scales would yield similarly adequate internal consistency results to the original validation sample [30] and the veteran sample [36]. In addition, it was hypothesized that there would be minor differences in clinical scale scores between the four samples. A moderate to significant difference was not hypothesized as symptoms associated with individuals exposed to blast injuries and PTSD groups often overlap extensively.

2. Methods

2.1. Participants

The University of North Carolina Wilmington Institutional Review Board (IRB) approved this research (protocol number H1213-145; approval date 8 December 2015). A dataset of psychological testing results of 893 military personnel in the U.S. Marine Corps and the US Navy was compiled by the Roger W. Sperry Neuropsychology Laboratory at the University of North Carolina Wilmington in collaboration with neuropsychologists in Carolina Psychological Health Services, a private psychological practice serving Marines and sailors of Camp Lejeune military base located in Jacksonville, NC. Participants were referred to Carolina Psychological Health Services by military neurologists and other qualified medical officers from the Naval Hospital in Camp Lejeune for neuropsychological evaluation due to reported cognitive deficits because of military deployment (i.e., head injury due to exposure to blast injuries). Premorbid (e.g., Armed Services Vocational Aptitude Battery (ASVAB)) and demographic variables (e.g., education) were gathered on everyone before each participant was individually assessed and interviewed over two days using a neuropsychological test battery.

Of the 893 individuals in the dataset, 670 completed the TSI. The participants' average age was 26.06 (SD = 6.19), and most were male (n = 651) rather than female (n = 18). Mean educational attainment was 12.50 years (SD = 1.13). The sample was identified as European American (n = 486), African American (n = 35), Hispanic (n = 40), Asian American (n = 5), American Indian (n = 2), and Pacific Islander (n = 2). This sample is representative of the Marine Corps population [39]. The number of deployments ranged from 0–10, averaging 1.93 (SD = 1.31). The breakdown of location of deployments is as follows: 54.18% Iraq, 16.27% Afghanistan, 13.73% both Iraq and Afghanistan, and 2.54% home base. The remaining participants did not specify the location of deployment.

Furthermore, participants were categorized into four groups: those with a history of blast exposures (i.e., blast exposed), those with PTSD (i.e., PTSD), those with both blast exposures and PTSD (i.e., blast exposed and PTSD), and those with neither blast exposures nor PTSD (i.e., neither). Blast exposures were categorized based on individuals' self-reports (i.e., they reported that they had experienced blast injuries in the past). PTSD was classified by a clinical neuropsychologist based on a clinical interview and psychological testing. Thus, 157 (23.43%) of participants were categorized as blast exposure, 90 (13.43%) as PTSD, 283 (42.24%) as blast exposure and PTSD, and 140 (20.90%) as neither. Please see [31] for additional details regarding acquiring this dataset.

2.2. Measure

The TSI [30] is a 100-item, structured self-report measure designed to assess one's psychological functioning after experiencing traumatic events. The examinee is asked to respond to a series of questions and indicate the occurrence of specific thoughts, behaviors, or feelings. Answers are composed of a four-point scale, ranging from zero (never) to three (often). The raw scores are summed for each scale and transformed into t-scores using normative data. Each scale has a mean T-score of 50 and a standard deviation of 10. Higher scores indicate a greater level of distress. The TSI contains three validity scales: Inconsistent Response, Atypical Response, and Response Level. The 10 clinical scales include Anxious Arousal, Depression, Anger/Irritability, Intrusive Experiences, Defensive Avoidance, Dissociation, Sexual Concerns, Dysfunctional Sexual Behavior, Impaired Self Reference, and Tension Reduction Behavior. The first five clinical scales closely mirror DSM-IV-TR [40], whereas the other assesses other symptoms reported by trauma survivors, making it a comprehensive measure.

2.3. Procedure

Participants were referred for a neuropsychological evaluation to assess current cognitive functioning due to reported cognitive or emotional symptoms or complaints. Upon arrival, participants were informed of the purpose of the evaluation, the examination's characteristics, and the limits of confidentiality. Both oral and written informed consent was obtained from each participant. Each assessment was carried out in the following four stages: patient history, clinical interview, neuropsychological test battery, and follow-up session. The first three stages culminated in helping form a diagnosis per the DSM-IV, the latest version at the beginning of data collection.

In terms of patient history, the patient's medical record, documentation, and Armed Services Vocational Aptitude Battery (ASVAB) scores were reviewed along with educational history, reports from supervisors, and occupational history. The clinical interview consisted of recording information such as general presentation, mood and affect, orientation to place and time, suicidal or homicidal ideation/intent, sleep disturbance, and any additional observations reported by the interviewer. The neuropsychological test battery consisted of 15 tests, including TSI. Please see [31] for further details regarding the neuropsychological evaluation procedure.

2.4. Analytic Plan

Statistical analyses were performed with SPSS. The reliability estimates of the TSI validity and clinical scales were analyzed through internal consistency estimates and mean item inter-correlations (MICs). As the number of items influences Cronbach's alpha coefficients in a scale, MICs were calculated to provide a more precise estimate of item homogeneity [41,42]. We then analyzed the *t*-scores for each of the TSI scales through a one-way multivariate analysis of variance (MANOVA) to determine if there were differences across the four groups: blast exposed, PTSD, blast exposed, PTSD, and neither. Pillai's trace is reported as a violation of the homogeneity of covariance matrices [43]. Post hoc tests were used to explore the differences in multiple groups' means while controlling the experiment-wise error rate. Here, Games–Howell post hoc tests were conducted due to heterogeneity of variance, and point estimate effect size *d* was calculated to articulate the magnitude of difference between the four groups for each variable [44]. This was followed by a discriminant function analysis to assess the ability of the TSI scales to classify individuals into the four groups correctly.

3. Results

3.1. Reliability Estimates

Cronbach's alpha and mean item inter-correlations (MIC) were calculated for this sample of active-duty military personnel (see Table 1). Cronbach's alpha estimates ranged from 0.75 to 0.93 for the validity scales and from 0.75 to 0.93 for the clinical scales. Thus, all validity and clinical scales exceeded the 0.70 criterion set by [42]. These alpha coefficients were slightly higher than the [30] Navy validation sample and [36] veteran sample, also presented in Table 1. The MICs of the scales range from 0.23 to 0.63. Although some values are outside the optimal range of 0.20–0.40, a range of 0.10–0.50 is considered acceptable by [41]; despite this more lenient cut-off, Depression, Anger/Irritability, Intrusive Experiences, and Sexual Concerns exceeded the optimal range.

Table 1. Cronbach's alpha (α) and mean item inter-correlations (MIC) for the TSI scales.

Scale	N (Items)	α	α [a]	α [b]	MIC
Validity Scales					
INC	19	0.93	0.75	-	0.40
ATR	10	0.75	0.78	-	0.23
RL	10	0.84	0.55	-	0.46
Clinical Scales					
AA	8	0.86	0.82	0.77	0.42
D	8	0.92	0.88	0.86	0.58
AI	9	0.93	0.88	0.91	0.60
IE	8	0.93	0.87	0.86	0.63
DA	8	0.89	0.87	0.80	0.50
DIS	9	0.86	0.84	0.82	0.41
SC	9	0.84	0.83	0.83	0.65
DSB	9	0.83	0.85	0.86	0.35
ISR	9	0.87	0.85	0.84	0.41
TRB	8	0.75	0.76	0.73	0.27

[a] Coefficients presented are from the [30] Navy validation sample; [b] Coefficients presented are from the [36] veteran sample. INC = Inconsistent Response; ATR = Atypical Response Scale; RL = Response Level; AA = Anxious Arousal; D = Depression; AI = Anger/Irritability; IE = Intrusive Experiences; DA = Defensive Avoidance; DIS = Dissociation; SC = Sexual Concerns; DSB = Dysfunctional Sexual Behavior; ISR = Impaired Self Reference; TRB = Tension Reduction Behavior.

3.2. Group Differences on the TSI Validity and Clinical Scales

Group mean, and standard deviations of the TSI *t*-scores for validity and clinical scales are depicted in Table 2 and graphically in Figure 1. Though validity scale scores are generally consistent among the four groups, the groups appear to vary in the majority of the clinical scales, with the two PTSD samples having higher *t*-scores than the two samples without PTSD.

Table 2. Group differences on TSI scales between the blast-exposed, PTSD, both, and neither samples.

Scale	Blast (N = 157) M (SD)	PTSD (N = 90) M (SD)	Both (N = 283) M (SD)	Neither (N = 140) M (SD)	MANOVA *p*-Value
		Validity Scales			
INC	54.59 (13.39)	65.18 (18.35)	63.43 (14.44)	60.42 (17.28)	0.000
ATR	48.84 (10.16)	48.30 (11.93)	46.16 (10.09)	46.97 (8.15)	0.000
RL	50.13 (7.65)	51.67 (9.17)	51.11 (7.47)	50.54 (9.07)	0.793
		Clinical Scales			
AA	58.76 (11.40)	66.67 (8.86)	67.02 (8.03)	59.96 (11.59)	0.000
D	51.02 (10.28)	61.03 (10.41)	58.45 (10.58)	55.39 (11.80)	0.000
AI	59.80 (13.10)	68.83 (9.95)	69.35 (9.52)	63.02 (13.02)	0.000
IE	60.83 (13.88)	72.13 (11.81)	72.08 (10.86)	63.70 (13.64)	0.000
DA	55.35 (11.07)	65.43 (8.86)	64.86 (8.91)	57.97 (10.16)	0.000
DIS	59.61 (13.32)	70.83 (12.07)	69.28 (11.33)	63.57 (13.09)	0.000
SC	50.38 (9.09)	56.60 (11.78)	55.27 (11.64)	52.54 (10.73)	0.000
DSB	52.73 (11.57)	58.52 (14.53)	56.70 (13.06)	56.28 (14.13)	0.008
ISR	54.09 (11.51)	64.40 (10.44)	61.89 (9.84)	58.47 (12.18)	0.000
TRB	54.97 (11.93)	64.53 (14.07)	63.01 (12.53)	58.26 (14.34)	0.000

INC = Inconsistent Response; ATR = Atypical Response Scale; RL = Response Level; AA = Anxious Arousal; D = Depression; AI = Anger/Irritability; IE = Intrusive Experiences; DA = Defensive Avoidance; DIS = Dissociation; SC = Sexual Concerns; DSB = Dysfunctional Sexual Behavior; ISR = Impaired Self-Reference; TRB = Tension Reduction Behavior.

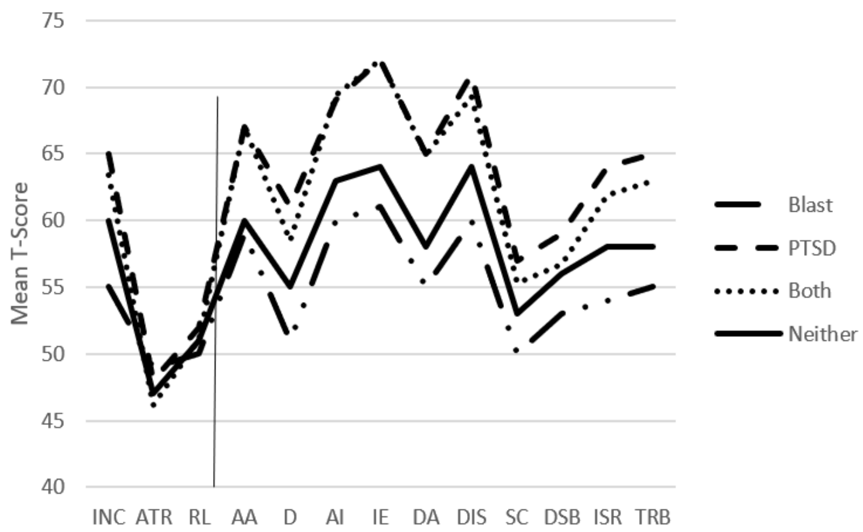

Figure 1. Mean TSI profiles for the blast exposed, PTSD, both, and neither samples. INC = Inconsistent Response; ATR = Atypical Response Scale; RL = Response Level; AA = Anxious Arousal; D = Depression; AI= Anger/Irritability; IE = Intrusive Experiences; DA = Defensive Avoidance; DIS = Dissociation; SC = Sexual Concerns; DSB = Dysfunctional Sexual Behavior; ISR = Impaired Self Reference; TRB = Tension Reduction Behavior.

The omnibus *F* test for the one-way MANOVA with TSI validity and clinical scales as the dependent variables was conducted to assess significant differences between the four groups. A significant Box's *M* test ($p < 0.001$) indicated heterogeneity of covariance matrices of the dependent variables across the groups. Using Pillai's trace, there was a significant difference between groups on TSI scale t-scores, $V = 0.25$, $F(39,1830) = 4.23$, $p < 0.001$, partial $h^2 = 0.08$. Given the significance of the overall test, differences in individual TSI scales across the four groups were examined. These comparisons indicated that all TSI scale t-scores were significant except for Response Level (see Table 2).

3.3. Validity Scales

As there were significant differences in Inconsistent Response and Atypical Response, post hoc Games–Howell analyses were examined to identify differences between the groups on these validity scales. The Games–Howell post hoc results and corresponding effect sizes can be found in Table 3. Medium effect sizes on Inconsistent Response were found for the blast exposed only compared with PTSD, both blast exposed and PTSD, and neither blast exposed nor PTSD, with the blast-exposed group scoring significantly lower than the other groups. Small effect sizes on Atypical Response were found for the blast-exposed only compared with both blast-exposed and PTSD, and for the blast-exposed and PTSD compared with neither blast-exposed nor PTSD groups, with the blast-exposed group scoring higher than those with both blast exposed and PTSD, and neither blast exposed nor PTSD scoring more elevated than those with both blast exposed and PTSD.

Table 3. Differences in the TSI between the blast-exposed, PTSD, both, and neither samples.

Scale	d_1	d_2	d_3	d_4	d_5	d_6
			Validity Scales			
INC	−0.66 **	−0.63 **	−0.38 *	0.11	0.27	0.19
ATR	0.05	0.26 **	0.20	0.19	0.13	−0.09 *
			Clinical Scales			
AA	−0.77 **	−0.84 **	−0.10	−0.04	0.65 **	0.71 **
D	−0.97 **	−0.71 **	−0.39 *	0.25	0.51 *	0.27
AI	−0.78 **	−0.83 **	−0.25	−0.05	0.50 *	0.56 **
IE	−0.88 **	−0.90 **	−0.21	0.00	0.66 **	0.68 **
DA	−1.01 **	−0.95 **	−0.25	0.06	0.78 **	0.72 **
DIS	−0.88 **	−0.78 **	−0.30 *	0.13	0.58 *	0.47 **
SC	−0.59 *	−0.47 **	−0.22	0.11	0.36	0.24
DSB	−0.44 *	−0.32 *	−0.27	0.13	0.16	0.03
ISR	−0.94 **	−0.73 **	−0.37 *	0.25	0.52 *	0.31
TRB	−0.73 **	−0.66 **	−0.25	0.11	0.44 *	0.35 *

* According to Games–Howell post hoc tests, the difference is significant at the $p < 0.05$ level; ** According to Games–Howell post hoc tests the difference is significant at the $p < 0.01$ level; d_1 = Cohen's *d* blast only compared with PTSD only; d_2 = Cohen's *d* blast only compared with both blast and PTSD; d_3 = Cohen's *d* blast only compared with neither blast nor PTSD; d_4 = Cohen's *d* PTSD only compared with both blast and PTSD; d_5= Cohen's *d* PTSD only compared with neither blast nor PTSD; d_6 = Cohen's *d* both blast and PTSD compared with neither blast nor PTSD; INC = Inconsistent Response; ATR = Atypical Response Scale; AA = Anxious Arousal; D = Depression; AI = Anger/Irritability; IE = Intrusive Experiences; DA = Defensive Avoidance; DIS = Dissociation; SC = Sexual Concerns; DSB = Dysfunctional Sexual Behavior; ISR = Impaired Self-Reference; TRB = Tension Reduction Behavior.

3.4. Clinical Scales

All clinical scales had significant differences between groups. As such, post hoc Games–Howell analyses were examined for the 10 clinical scales to identify where these differences occurred. In Table 3, moderate to large effect sizes were found on all clinical scales between the blast exposed only compared with PTSD only (−0.44 to −1.01), and blast exposed only compared with both blast exposed and PTSD (−0.32 to −0.95), with the blast-exposed group having significantly lower scores on all clinical scales. In addition, the blast-exposed group had significantly lower scores than the blast-exposed or PTSD diagnosis group on Depression, Dissociation, and Self-Reference, with effect sizes falling in the small to medium range. There were no significant differences when comparing PTSD only and both PTSD and blast-exposed groups. In addition, the PTSD-only group had significantly higher means on Anxious Arousal, Depression, Anger/Irritability, Intrusive Experiences, Defensive Avoidance, Dissociation, and Tension Reduction Behavior, with effect sizes falling in the medium to extensive range (0.44–0.78) in comparison with the neither blast-exposed nor PTSD group. Finally, similar differences were found between both PTSD and TBI groups and the neither blast-exposed nor PTSD group, with both PTSD and TBI groups having significantly higher means of Anxious Arousal, Anger/Irritability, Intrusive Experiences, Defensive Avoidance, Dissociation, and Tension Reduction Behavior, with effect sizes falling in the medium to extensive range (0.47–0.72).

3.5. Discriminant Function Analysis

The MANOVA was followed with a discriminant function analysis, revealing three discriminant functions. The first explained 79.20% of the variance, canonical $R^2 = 0.19$, and the second explained 16.60% of the variance, canonical $R^2 = 0.05$, and the third explained 4.20% of the variance, $R^2 = 0.01$. These functions were able to classify 52.40% of cases correctly (see Table 4). The classification analysis indicated that an optimally weighted combination of scales correctly predicted 295 of 342 PTSD-positive cases (86.26% sensitivity) and 153 of 282 PTSD-negative cases (54.26% specificity). These functions significantly differentiated the four groups, $\lambda = 0.76$, $\chi^2(39) = 165.75$, $p < .001$. Removing the first function revealed that the second and third functions continued differentiating the cohorts, $\lambda = 0.94$, $\chi^2(24) = 36.94$, $p = 0.044$. However, removing the first two functions indicated that the third function alone did not differentiate the groups $\lambda = 0.99$, $\chi^2(11) = 7.59$, $p = 0.750$. The first function differentiated PTSD only and both PTSD and blast-exposed groups from the blast-exposed only and neither PTSD nor blast-exposed groups. The second function differentiated the blast-exposed only and both blast-exposed and PTSD groups from the PTSD only and neither PTSD nor blast-exposed groups. The third function differentiated the blast-exposed only and PTSD only from both blast-exposed and PTSD and neither blast-exposed nor PTSD groups (see Table 5).

Table 4. Classification results.

		Predicted Group Membership			
Actual Group	Number of Cases	Blast Exposed	PTSD	Both	Neither
Blast	149	76 (51.0%)	1 (0.7%)	58 (38.9%)	14 (9.4%)
PTSD	81	6 (7.4%)	3 (3.7%)	63 (77.8%)	9 (11.1%)
Both	261	20 (7.7%)	4 (1.5%)	225 (86.2%)	12 (4.6%)
Neither	133	40 (30.1%)	0 (0.0%)	70 (52.6%)	23 (17.3%)

Table 5. Group centroids.

	Function		
Group	1	2	3
Blast Exposed	−0.641	−0.203	0.084
PTSD	0.405	0.324	0.218
Both	0.438	−0.132	−0.050
Neither	−0.388	0.289	−0.128

4. Discussion

Military personnel are at high risk for psychological trauma, given the nature of their occupation. Trauma in the military differs from civilian trauma in symptomology and trauma exposure. Furthermore, PTSD rates in the military are significantly higher in veterans who returned from wars in Iraq and Afghanistan relative to other war eras, which underscores the need for better diagnosis and assessment. The Veteran Administration has long recommended the use of TSI due to its versatility with five clinical scales that closely mirror DSM-IV diagnostic criteria and other scales that reflect additional trauma symptoms. However, previous research with military personnel has been limited due to sample size. This is the first study examining military trauma by assessing the utility of the TSI using a large active-duty military sample that served in OIF and OEF to discriminate between blast injuries, diagnosed with PTSD, both exposed to blast injuries and diagnosed with PTSD, and not exposed to blast injuries nor diagnosed with PTSD. Results showed continued support for the utility of the TSI among active-duty military personnel.

The first hypothesis that the TSI's scales would yield similarly adequate internal consistency results to both the original validation sample [30] and the veteran sample [36] was supported in that the internal consistency estimates were all high (Cronbach's alpha's range 0.75–0.93). However, the MICs for the Depression, Anger/Irritability, Intrusive Experiences, and Sexual Concerns scales exceeded the optimal cut-off scores, with MIC estimates of 0.58, 0.60, 0.63, and 0.65, respectively, suggesting that there is some redundancy in item content which can be revised with advanced statistical methods such as item response theory. As Loevinger [45] points out, item correlations that are too high can limit the validity of a construct. Further studies are needed to investigate item homogeneity and the potential for eliminating redundant items. Given that this was one of the goals that led to the TSI revision, it was not a goal of the current study.

The second hypothesis that there would be minor differences in clinical scale scores between the four samples was partially supported. That is, 12 of the 13 TSI scales displayed significant differences between groups. Though the TSI could significantly distinguish the blast-exposed and no blast-exposed groups with small effect sizes on Depression, Dissociation, and Impaired Self-Reference, medium to large effect sizes were found when comparing the PTSD to the no PTSD groups. This medium to large effect size suggests the TSI can discriminate between PTSD and no PTSD groups as the two PTSD groups were significantly higher on all clinical scale scores when compared with the blast-exposed only and neither blast-exposed nor PTSD groups. Notably, large effect sizes were identified for the three TSI clinical scales that are associated with the DSM-IV diagnostic criteria for PTSD: Defensive Avoidance relates to the intrusion cluster ($d_1 = -1.01$; $d_2 = -0.95$), Intrusive Experiences relate to the avoidance cluster ($d_1 = -0.88$; $d_2 = -0.90$), and Anxious Arousal relates to the altered arousal and reactivity cluster ($d_1 = -0.77$; $d_2 = -0.084$). Overall, results suggest that TSI can distinguish between symptoms associated with blast exposure and symptoms associated with PTSD despite the extensive overlap.

Finally, discriminant function analysis indicated that the TSI correctly classified 86.26% of true-positive and 54.26% of true-negative PTSD cases. While the sensitivity of the TSI in this sample is comparable with that found in the Italian version of the instrument (90.00%), the specificity is significantly lower (91.40%) [46]. This discrepancy likely stems from the classification methods used in this study. Given that specificity characteristics (the ability of the TSI to identify true-negative PTSD cases correctly) are relatively poor (54.26%), albeit slightly greater than chance, results suggest the TSI should be used with caution when used to rule out patients that do not have PTSD. Moreover, due to the high concurrent co-morbidity rates of PTSD and TBI amongst personnel returning from the wars in Iraq and Afghanistan, the TSI should not be used independently to conclude whether presenting symptoms are correctly attributed to PTSD or are better explained by TBI or another comorbid disorder. A thorough assessment is necessary to guide this. This study was limited as group assignment was based on clinical diagnosis and self-report of blast exposure. Although the current assessment of TBI relies heavily on behavioral observations and patient recall, historically, self-reporting has not been the most reliable research method [47].

Additionally, the group that was characterized as neither PTSD nor TBI is flawed. It is unknown whether these individuals would be warranted a diagnosis or not. All that is known is that the records show no diagnoses were made for PTSD or TBI. Future studies need to analyze the utility of the TSI with known group designs in this population. Another limitation of this study relates to the biased sample; individuals not suspected of cognitive impairment were not referred for neuropsychological assessment. Therefore, this sample only contains those who were referred for an assessment due to cognitive impairment and did not allow for the assessment of the full spectrum of PTSD symptom severity. Finally, since the release of the TSI-2, the TSI is not commonly used. However, the TSI was included in the battery in 2008, well before the TSI-2 was released in 2016. In addition, there are no conceptual differences between the two versions of the two tests [34]. It was not until 2020 that the first publication using the unprecedented and large dataset was published. Therefore, despite the TSI being outdated presently, the findings provide support for the application of the TSI to measure PTSD in active military samples despite significant overlap with blast exposure. Nevertheless, further validation with the TSI-2 is needed.

Notwithstanding these limitations, the results of this study indicate that the TSI performs well not only with civilian trauma victims (e.g., [30,35,46]) and veterans [9,36,37] but also with active-duty military personnel. Further, these findings provide further support to the concept that trauma is multifaceted and is expressed differently in varied populations. The need for such a test is likely to grow as the number of military personnel seeking help for PTSD has increased [48]. The rising number of personnel who suffer from PTSD continues to be a severe public health problem. Accurate assessment and diagnosis may help identify those in need of treatment. As such, the TSI may be helpful in the assessment and monitoring of PTSD symptoms in active military personnel.

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