EFFECTS OF TRAUMATIC BRAIN INJURY ON SEVERITY OF PTSD SYMPTOM CLUSTERS AMONG VETERANS WITH COMBAT-RELATED TRAUMA

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BY

Cecilia LaFosse-Stumpf

APPROVED:

Courtney Baker, Ph.D.
Director of Thesis

Claire Houtsma, Ph.D.
Second Reader

Marline Otte, Ph.D.
Third Reader
Cecilia LaFosse-Stumpf. Effects of Traumatic Brain Injury on Severity of PTSD Symptom Clusters Among Veterans with Combat-Related Trauma.

(Professor Courtney Baker, Psychology)

The topic of this thesis is the effects of traumatic brain injuries (TBI) on the severity of PTSD symptom clusters, as defined by the Diagnostic and Statistical Manual for Mental Disorders, fifth edition (DSM-5), among veterans with combat-related trauma. These symptom clusters include re-experiencing, avoidance, negative alterations in cognition and mood, and hyperarousal. This study aims to investigate the hypothesis that veterans with combat-related trauma in addition to a traumatic brain injury (TBI) will exhibit different symptom cluster severities than veterans with combat-related trauma and no TBI. An additional possible aim of this study is to evaluate the impact of the elevated severity of these symptom clusters on possible treatment plans for veterans with comorbid combat-related trauma and traumatic brain injury as well as on future research to be conducted based on the findings of this study.

*Keywords:* traumatic brain injury, posttraumatic stress disorder, veterans, combat, avoidance, cognition, mood, hyperarousal, re-experiencing
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Introduction

Originally referred to as “shell shock” or “soldier’s heart,” posttraumatic stress disorder (PTSD) was first recognized in the trenches of WWI, where soldiers would often enter states of near paralysis due to the traumas of combat. Now a century later, the state of shock caused by the experience of a traumatic event is known as PTSD and is well documented both within the military and in civilian life. However, in the minds of many, PTSD is still heavily tied to the context of combat, a connection that is only strengthened by statistics regarding the prevalence of diagnosis among combat veterans and active-duty military members. According to the Department of Veterans Affairs (VA), 29% of veterans who served in Operation Iraqi Freedom and Operation Enduring Freedom are diagnosed with posttraumatic stress disorder (PTSD) at some point in their life (U.S. Department of Veterans Affairs, 2018).

Modern advancements in psychology and neuroscience allow researchers to examine relationships between other common combat-related experiences and PTSD symptoms and severity. One such link may be found between traumatic brain injuries (TBIs) and presentation of PTSD symptoms. The possibility of a link between experiencing a TBI and heightened PTSD symptoms could provide a promising realm of study, as traumatic brain injuries account for a large percentage of all injuries gained in combat. More than 450,000 U.S service members were diagnosed with a combat-related traumatic brain injury (TBI) from 2000 to 2021, which is associated with greater likelihood of comorbid PTSD and depression (“TBI Among Service Members,” 2022). Despite some overlap in affected areas of functioning and affected brain regions, research
is currently mixed regarding the impact of comorbid TBI on the severity of PTSD symptoms.

**Posttraumatic Stress Disorder (PTSD) in the Military**

Posttraumatic stress disorder (PTSD), as defined by the American Psychiatric Association, is a psychiatric disorder that may occur in individuals who have experienced or witnessed a traumatic event or a series of traumatic events, such as combat, natural disasters, or domestic violence (Taylor-Desir, 2022). In order to receive a diagnosis of PTSD, one must exhibit symptoms within the four diagnostic symptom clusters—intrusion, avoidance, negative alterations in cognition or mood, and hyperarousal—for at least one month following the traumatic experience, as outlined by the Diagnostic and Statistical Manual of Mental Disorders, 5th Edition (DSM-5) (U.S. Department of Veterans Affairs, 2013). Represented in Criterion B of the DSM-5 criteria for PTSD diagnosis, the intrusion symptom cluster includes unwanted thoughts of the trauma in the form of flashbacks, nightmares, memories, emotional distress, or physical reactivity, with the presence of at least one of the listed symptoms being necessary for a diagnosis. The avoidance symptom cluster, as outlined in Criterion C, requires that an individual must display an avoidance of trauma-related thoughts and feelings, trauma-related reminders, or both to be diagnosed with PTSD. Criterion D outlines the negative alterations in cognition or mood symptom cluster. In contrast to Criterion B and C, one must display at least two symptoms from Criterion D to be considered for diagnosis, which include inability to remember key features of the trauma, negative thoughts about oneself and the world, exaggerated blame of oneself or others for the trauma, negative affect, decreased interest, feelings of isolation, and difficulty experiencing positive feelings. Finally,
Criterion E represents hyperarousal symptoms, with at least two of the following symptoms being required for diagnosis: irritability or aggression, risky or destructive behavior, hypervigilance, increased startle reaction, difficulty concentrating, and difficulty sleeping (U.S. Department of Veterans Affairs, 2013). Some of the most commonly experienced symptoms among those with posttraumatic stress disorder include frequent and distressing flashbacks or dreams of the traumatic event, avoidance of stimuli related to the trauma, consistent negative emotional state, irritability, problems sleeping, hypervigilance, and lack of concentration (Center for Substance Abuse Treatment, 2014).

Due to the nature of military service, which often involves exposure to violence or violent images and high stress environments, service members have a heightened chance of experiencing a trauma that may lead to the development of PTSD within their lifetime. According to the U.S. Department of Veterans Affairs (2018), 7% of veterans will have PTSD at some point during their life, compared to 6% of non-veterans. Additionally, this percentage varies based on other factors such as gender, deployment, and war zone served in. Research done by the VA has also shown that female veterans and active-duty military members are more likely to develop PTSD, with 13% of female service members being diagnosed with PTSD at some point in their life span as opposed to only 6% of their male peers, a difference that may be linked to Military Sexual Trauma (MST). In addition to female gender being a risk factor for the development of PTSD within the military, service members who are deployed at least once during their contract are at an increased risk for PTSD, with three times as many deployed veterans receiving a diagnosis than non-deployed veterans (U.S. Department of Veterans Affairs, 2018). In sum, while different personal and environmental characteristics may lead some service
members to be at an increased risk of developing posttraumatic stress disorder, the nature of military service is linked to an overall heightened chance of experiencing a trauma that may lead to the development of PTSD.

**Traumatic Brain Injury (TBI) in the Military**

According to the Center for Disease Control, a traumatic brain injury is defined as “a disruption in the normal function of the brain that can be caused by a bump, blow, or jolt to the head, or penetrating head injury” (Traumatic Brain Injury, 2022). In addition to PTSD, TBIs constitute a large number of all military-related diagnoses. Between 2000 and 2017, the Department of Defense reported over 375,000 diagnosed traumatic brain injuries among members of the United States military (U.S. Department of Veterans Affairs, 2018).

However, among all traumatic brain injuries gained in the military, blast-related TBIs, or those caused by the detonation of an explosive and the resulting shock wave, are considered most common, making up a large percentage of all combat-related injuries sustained in recent wars. A study examining data from 115 combat-exposed service members revealed that blast-related TBIs made up 52% of all TBIs gained in combat and 63% of all TBIs of those wounded in action (Rosenfeld et al., 2013). Due to the prevalence of blast-related traumatic brain injuries among service members, research has been conducted to study the effects of this TBI subtype as opposed to blunt force TBIs. One such study found that mice that were injured with a mild blast induced TBI showed decreased dendritic branching in the hippocampus and the cortex, specifically within the middle region of the parietal cortex (Ratliff et al., 2020). Additional studies into the effects of blast related TBIs have also found abnormalities in dendritic spine density and
branching in areas of the amygdala that are consistent with chronic stress models (Ratliff et al., 2019).

Considering the findings of current studies on this topic, the brain regions most often affected by blast-related traumatic brain injuries are those implicated in neurologic functioning in the areas of memory, learning, spatial reasoning, sensation input, and fear and stress responses. These findings align with the most common symptoms of TBIs, which include reduced memory, lack of concentration, irritability, and reductions or alterations in the five senses (U.S. Department of Veterans Affairs, 2018).

**Previous Research on the Effects of TBI on PTSD Symptoms**

Previous studies have found that the neurological effects of both PTSD and TBI overlap in the areas of attention, working memory, executive functioning, and episodic memory, while neuroimaging studies have found abnormalities in prefrontal and temporal brain regions in individuals with PTSD and with one or more TBIs, respectively (Kaloyan et al., 2014). The temporal brain region is responsible for the processing of emotions, language, and some aspects of vision, while the prefrontal cortex plays a primary role in cognitive functioning. Abnormalities in these brain regions can be directly linked to the common symptoms of both PTSD and TBI, which include negative affect and increased arousal (U.S. Department of Veterans Affairs, 2018).

Some studies indicate that blast related TBIs specifically can lead to damage to the amygdala, which is implicated in emotional processing and is especially associated with fear and anxiety responses (Ratliff et al., 2019). Notably, these same processes are often disrupted among those with PTSD. A 2013 study further investigated the neural
basis of symptoms associated with PTSD in a sample of veterans who served in
Operation Iraqi Freedom and Operation Enduring Freedom, and through neuroimaging,
researchers found a significant reduction in volume in the bilateral anterior amygdala in
individuals with comorbid PTSD and blast related TBI as opposed to peers with no PTSD
and/or TBI (Depue et al., 2014). This sample of veterans with reduced amygdalar volume
also exhibited poorer inhibitory control as compared to their peers, thus providing a
neurological basis for the argument that comorbid PTSD and TBI can lead to different
behavioral and cognitive presentations than either PTSD or TBI alone (Depue et al.,
2014). Additionally, this reduced inhibitory control that was found in veterans with
reduced amygdalar volume may be connected to greater PTSD symptom cluster severity,
specifically response inhibition (DeGutis et al., 2015). Because response inhibition refers
to an individual’s ability to suppress actions that are inappropriate to a given context, a
lower response inhibition being linked with both increased PTSD symptom cluster
severity and reduced amygdalar volume, as seen in veterans with comorbid PTSD and
TBI, lends evidence to the argument that TBI and PTSD symptoms may be linked and
TBI status may affect PTSD symptom severity.

Present Study

Due to the cognitive overlaps in symptoms of PTSD and TBI in addition to
neurological abnormalities found in related brain regions in those with either diagnosis,
the present study aims to determine the relationship between traumatic brain injury and
severity of PTSD symptom clusters among veterans with combat-related trauma. Based
upon the findings of prior research on veterans with comorbid posttraumatic stress
disorder and TBI, findings which heavily implicate amygdalar abnormalities in the
symptomology of both diagnoses, it is hypothesized that veterans who have experienced at least one traumatic brain injury will experience more severe PTSD symptoms, especially within the hyperarousal and negative mood symptom clusters.

Method

Participants

This study includes data collected from a sample of 157 United States veterans who visited a PTSD specialty clinic at the Southeast Louisiana VA Medical Center in New Orleans. Of those who visited the PTSD specialty clinic and were administered the intake evaluation assessments, only those who reported experiencing combat-related trauma and who have been diagnosed with PTSD had their data included in this study. The 157 participants included 60 (38.2%) with a history of traumatic brain injury (TBI) history, 92 (58.6%) with no TBI history, and 5 (3.2%) with missing TBI information. It is also notable that 151 participants, or 96.2%, were male while only 6, or 3.8%, were female. Nearly all participants were either Caucasian (48.4%) or Black/African American (43.3%). Operation Iraqi Freedom (OIF) and Operation Enduring Freedom (OEF) were the most frequent warzones served in, with 112 of the 157 participants, or 71.3%, reporting participation in OEF/OIF. Of those who did not report service in OEF/OIF, 12 participants served in Vietnam, 15 served in Operation Desert Storm, 2 served in unlisted warzones, 2 served in no warzones, and 14 served in multiple warzones. In addition to the inclusion of combat experiences in multiple war zones, all branches of the military apart from the Coast Guard were represented. 84 participants (53.5%) served in the Army, 15 (9.6%) served in the Navy, 22 (14.0%) served in the Marine Corps, 3 (1.9%) served in
the Air Force, 25 (15.9%) served in the National Guard, and 7 (4.5%) served in multiple branches.

**Materials and Procedure**

As part of their intake evaluation at the PTSD specialty clinic, the veterans in the sample were administered a battery of assessments and self-report questionnaires, including the Clinician Administered PTSD Scale for DSM-5 (CAPS-5), the Anxiety Sensitivity Index-3 (ASI-3), the Intolerance of Uncertainty Scale- short form (IUS-12), the Posttraumatic Stress Disorder Checklist for DSM-5 with Criterion A (PCL-5), and the Patient Health Questionnaire (PHQ-9). These data were collected and organized by psychologists as part of routine clinical care at the Southeast Louisiana VA. Institutional Review Board approval was obtained to use this data for research purposes. For the purposes of this study, only data collected from the demographic questionnaire, which assessed for trauma exposure and traumatic brain injury (TBI) diagnoses, the CAPS-5, and the PCL-5 will be analyzed to determine the presence of mean differences in symptom cluster severity between those with TBI and those without TBI.

**Demographic Questionnaire.** As part of the intake evaluation packet, all participants were administered a series of demographic questions. This included queries regarding TBI status, age, gender, race, sexual orientation, education level, branch of service, war zone served in, and employment status. For the purposes of this study, only responses related to TBI status, which were binary yes TBI/no TBI responses, were included in the analysis. No information was included regarding TBI origin or number of TBIs experienced by each individual with a TBI in their medical history.
Clinician Administered PTSD Scale for DSM-5 (CAPS-5). The CAPS-5, which is considered a gold-standard PTSD assessment, is a structured interview consisting of 30-items aimed at assessing both current and lifelong PTSD diagnostic status and PTSD symptom severity. The questions included in the assessment discuss onset and duration of symptoms, functional impact of symptoms, and the presence of the DSM-5 PTSD symptoms. Each item is assessed for both frequency and intensity, which are then combined to provide a single symptom severity score with scores ranging from 0: Absent to 4: Extreme/incapacitating. Symptom cluster severity scores can be calculated by adding the individual symptom severity scores for the items corresponding to each cluster. Intrusion symptoms are represented by items one through five, avoidance symptoms by items six and seven, negative cognition and mood symptoms by items eight through fourteen, and hyperarousal symptoms by items fifteen through twenty. An example of an item testing for intrusion symptoms is “In the past month, have you had any unwanted memories of (EVENT) while you were awake, so not counting dreams?” (U.S. Department of Veterans Affairs, 2018).

Posttraumatic Stress Disorder Checklist for DSM-5 with Criterion A (PCL-5). The PCL-5 is a self-report questionnaire including 20 items aimed at measuring each of the DSM-5 PTSD symptom criteria. The 20 items include a list of symptoms with a prompt to rate the level of distress caused by each symptom within the last month using a five-point Likert scale from “not at all” to “extremely”. Although CAPS-5 is considered the gold standard in PTSD diagnosis, the PCL-5 can be utilized to provide a provisional diagnosis when necessary, as it is a self-report measure and not administered by a professional. Symptom cluster severity can be measured using the PCL-5 by summing
the scores of the item groups representing each of the four symptom clusters, with scores for each item ranging from 0: Not at all to 4: Extremely (U.S. Department of Veterans Affairs, 2022). A sample item provided by the Department of Veterans Affairs from the PCL-5 assessing for intrusion symptoms is “In the past month, how much were you been bothered by: "Repeated, disturbing, and unwanted memories of the stressful experience?"

**Results**

A series of independent samples t-tests were conducted to compare PTSD symptom cluster severity for veterans with combat-related trauma, with and without TBI. Results revealed a significant between group difference on PTSD hyperarousal symptoms as measured by the CAPS-5 by TBI status \( t(120.2) = -2.19, p = .03 \), such that individuals with PTSD and comorbid TBI demonstrated higher levels of hyperarousal \( M = 0.77, SD = 0.43 \) than individuals with PTSD only \( M = 0.59, SD = 0.49 \). The magnitude of the difference in the means (mean difference = -0.18, 95% CI [-.34, -.02]) was approximately medium (Cohen’s \( d = .47 \)).

There were no other statistically significant relationships found between TBI status and any of the other PTSD symptom clusters from the CAPS-5, including reexperiencing and avoidance. Additionally, the results of the independent samples t-tests between TBI and the subscales of the PCL-5 were also not significant, meaning only hyperarousal symptoms as measured by the CAPS-5 were found to have a significant between-groups difference by TBI status.
Discussion

This study aimed to determine the effects of traumatic brain injury on PTSD symptom cluster severity among veterans. The results of the current study suggest that veterans with comorbid TBI and combat-related PTSD may experience more severe hyperarousal symptoms, which may include verbal or physical aggression towards people with little or no provocation, destructive behavior, risk-taking, hypervigilance, heightened startle reaction, difficulty sleeping, and lack of concentration, than veterans with combat-related PTSD and no TBI (Sandy, 2021). These findings align with prior neuroimaging studies, which found reductions in volume and abnormalities in areas of the amygdala, the prefrontal cortex, and the temporal brain region in veterans with comorbid traumatic brain injuries and PTSD (Kaloyan et al., 2014). Due to the amygdala’s role in fear and anxiety responses as well as the roles of the prefrontal cortex and the temporal brain region in impulse-control, reasoning, and the processing of emotions, respectively, there is neurological support for the finding that experiencing at least one TBI can lead to increased hyperarousal symptoms in individuals with PTSD. However, further study should be conducted into the neurological relationship between increased hyperarousal symptoms and TBI, as these findings may improve understanding of PTSD presentation in veterans and help guide collaborative decisions with veterans regarding PTSD treatment.

Although this finding aligned with the initial hypothesis of this study, the findings only partially supported the hypotheses, as no significant between group differences were found across other PTSD symptom clusters. Because the hypothesis claimed that veterans who have experienced at least one traumatic brain injury will experience more severe
PTSD symptoms, especially within the hyperarousal and negative mood symptom clusters, the lack of relationship between traumatic brain injury and negative mood symptoms should be analyzed more in depth in future studies. Although abnormalities in the amygdala and prefrontal cortex, which are areas of the brain largely implicated in emotion and emotional regulation, have been found in individuals with comorbid PTSD and TBI, the lack of a significant between group difference in negative mood and cognition symptoms between those with TBI and those without in this analysis does not align with this finding (Ratliff et al., 2019).

**Limitations and Future Directions**

Although this study revealed a statistically significant relationship between TBI status and the severity of hyperarousal symptoms in veterans with PTSD, there were a number of limitations that could be improved in future studies. The data set used for analysis in this study originated from an established intake evaluation routine within a PTSD specialty clinic at the Southeast Louisiana VA Medical Center, meaning there was less flexibility in the depth of information collected and made available for research. For this reason, this study lacked data regarding the origin of the traumatic brain injuries reported by participants as well as data regarding the severity and the quantity of traumatic brain injuries experienced by each individual who responded “yes” to having a TBI in their history. Further studies into this topic could provide a more in-depth analysis of the effects of TBI on PTSD symptom cluster severity by also considering the effects of compounding TBIs as well as the effects of TBIs of a greater severity as opposed to those that are less severe. Additionally, information regarding the origin of the TBI, especially focusing on whether the injury was combat-related or related to a non-military context,
could add clarity to the finding that TBIs may be related to increased hyperarousal symptoms. Because criterion A for a PTSD diagnosis as stated by the Diagnostic and Statistical Manual of Mental Disorders, 5th Edition (DSM-5) states that an individual must experience a trauma, the trauma that leads to the onset of PTSD for many combat veterans may be the experience of an explosion, which could also lead to a blast-related TBI. In this case, it may not be possible to distinguish whether it is the TBI or the index trauma that may be leading to increased hyperarousal symptoms in an individual with comorbid PTSD and TBI. It is for this reason that expanding upon information regarding TBI history in participants would benefit the clarity, validity, and depth of findings in future studies on this topic, and the lack of this information presented limitations to the current study.

**Conclusion**

In the current study, a preliminary investigation into the effects of traumatic brain injuries on PTSD symptom cluster severity among veterans with combat-related trauma was conducted through the analysis of data collected at a PTSD specialty clinic within the Southeast Louisiana VA Medical Center. Through this analysis, it was discovered that there was a statistically significant relationship between TBI status and the severity of hyperarousal symptoms in which more severe symptom presentations were seen in those who had experienced a traumatic brain injury, thus offering insight into the neurological and psychological effects of TBIs. Although the findings of the study contradicted the predictions made in the hypothesis in the lack of a connection between TBI status and the severity of alternate symptom clusters, the discovery of increased hyperarousal symptoms aligns with current studies in the field.
Continued research, similar to this study, in the areas of traumatic brain injury, posttraumatic stress disorder, and other common physical and mental injures sustained during military service is important to not only improve diagnosis and understanding of differing symptom presentations in individuals but also to inform the development of new, more effective treatments and preventative measures aimed at reducing the number of service members who must handle the consequences of these diagnoses upon returning home.

**Figure 1**

*Difference in mean hyperarousal symptom levels between participants with a TBI and participants without a TBI.*
References


