2024

Development of an Objective Battery for PTSD

Kathryn O'Dell

DEVELOPMENT OF AN OBJECTIVE BATTERY FOR PTSD

by

KATHRYN D. SUNDERMAN
B.S., University of Central Florida, 2020

A thesis submitted in partial fulfillment of the requirements
for the degree of Master of Science
in the Department of Psychology
in the College of Sciences
at the University of Central Florida
Orlando, Florida

Summer Term
2024

Major Professor: Deborah C. Beidel

ABSTRACT

Posttraumatic Stress Disorder (PTSD) is marked by avoidance, arousal, re-experiencing, and negative mood and cognition. To date, these symptoms are assessed using self-report measures (e.g., the PCL-5) and clinician administered assessments (e.g., the CAPS-5). While these are the present gold-standard assessments for PTSD, they still are prone to bias on behalf of both the administrator and the patient. Presently, there is evidence that individuals with PTSD perform differently than individuals without PTSD on certain cognitive tasks that measure attention bias and avoidance behaviors. As such, creating a battery of these tasks may be a viable route for objectively measuring PTSD. In an effort to provide preliminary evidence for such a battery, we used three cognitive assessments [the Emotional Stroop Task (EST), the Visual Search Task (VST), and the Approach Avoidance Task (AAT)] to assess cognitive performance in veterans with PTSD, and veterans and civilians without PTSD. We hypothesized that veterans with PTSD would perform worse than the other groups (as measured by reaction times and accuracy scores) following the presentation of combat-related stimuli compared to negative and positive stimuli. The results indicated that veterans with PTSD were generally slower across all conditions in the EST, had lower accuracy scores on the VST, and were slower in the combat condition compared to the other control groups in the AAT. This study provides preliminary support for the hypothesis that a battery of cognitive tasks may be an effective tool for objectively identifying PTSD. Furthermore, we discuss important methodological ways in which future studies could improve the sensitivity of these tasks.

ACKNOWLEDGMENTS

I would like to thank my advisor and mentor, Dr. Deborah Beidel, for her unfailing patience, guidance, and encouragement, not just throughout the development of this master's thesis, but also throughout my graduate career. I would also like to thank the chair of my thesis committee, Dr. Clint Bowers, and committee members Drs. David Rozek and Mark Neider for their counsel and assistance throughout this project. Lastly, thank you to my friends and family for their unwavering love and support.

TABLE OF CONTENTS

LIST OF TABLES

INTRODUCTION

Posttraumatic Stress Disorder (PTSD) is characterized by avoidance, arousal, re-experiencing, negative beliefs or feelings, and must be a result of traumatic event where there was actual or perceived threat of death, serious injury, or sexual violence (APA, 2013). It is estimated that 50-90% of individuals in the general population will experience a traumatic event in their lifetime (Kilpatrick et al., 2013; National Center for PTSD, n.d.). Of those individuals, around 8% go on to develop PTSD (Kilpatrick et al. 2013). Certain occupations put individuals at higher risk for experiencing a traumatic event and consequently at added risk for developing PTSD. Such occupations include first responders, medical personnel, and perhaps most historically known, military personnel. In fact, it is estimated that as many as 17% of U.S. combat veterans may develop PTSD (Richardson et al., 2010). Similarly, almost all first responders (e.g., law enforcement, Emergency Medical Services [EMS]) will experience at least one traumatic event in their lifetimes, with prevalence of PTSD as high as 14% for some of those groups (Berger et al., 2011). At these rates, it is no surprise that PTSD is estimated to be the fourth most commonly diagnosed mental health disorder after depression, specific phobia, and social phobia (Kessler et al., 2012).

Left undetected and consequently untreated, PTSD can result in substantial distress and functional impairment. In general, PTSD has been associated with high levels of social and physical disability, considerable economic costs, and greater medical utilization. Frayne and colleagues (2010) found that compared to Operation Enduring Freedom (OEF) and Operation Iraqi Freedom (OIF) veterans with no mental health disorders, those with PTSD had a higher number of medical conditions; particularly spine, joint, and headache problems. Beyond physical health, PTSD has also been associated with lower income, lower occupational success, and poor social and family relationships (APA, 2013). That said, it is worth noting that some cases of PTSD do spontaneously remit (Morina et al., 2014). However many (particularly combat-related cases) do not, and while there are effective treatments for PTSD, the first step in effective treatment is accurate diagnosis and assessment.

Currently, there are several reliable and valid assessment measures for PTSD. Such measures include the self-report PTSD Checklist for DSM-5 (PCL-5) and the Clinician-Administered PTSD Scale (CAPS-5; Blevins et al. 2015; Weathers et al., 2013; Weathers et al., 2017). The CAPS-5, which is considered the gold-standard for diagnosing PTSD, is a 30-item structured interview that produces frequency and severity scores typically based on symptoms that reportedly occurred in the month prior to administration. These symptoms are organized into clusters that are congruent with the criteria outlined in the DSM-5. Broadly, these clusters are: Criterion A-exposure to a traumatic event, B-re-experiencing, C-avoidance, D-negative alterations in cognitions and mood, E-hyperarousal, and F-depersonalization and derealization. The PCL-5 is a self-report questionnaire with 20 items that also reflect the different symptom clusters of PTSD. That said, the PCL-5 is a symptom screener at best and unlike the CAPS-5 should not be the sole measure for diagnosing PTSD (Blevins et al. 2015, National Center for PTSD, n.d.). Rather, this measure is often used to monitor symptom change throughout treatment. In common, these measures rely on subjective judgment and as such are accompanied by a variety of limitations.

While widely accepted as well validated and reliable, there are still inherent limitations with structured interviews and self-report measures to which the CAPS-5 and PCL-5 are not immune. First, administrator bias poses a threat to the CAPS-5 in that test administrators may rate patient responses as more severe than actually exist. This could be for several reasons such as lack of training and/or lack of experience in conducting the assessments of PTSD. That said, even clinicians with good training or experience, by nature of being human, may still vary in their understanding of symptom criteria or use of rating scales, all of which could also result in inflated scores (Kramer, 2020). Second, with respect to both the CAPS-5 and PCL-5, patient self-reporting may result in the under and/or overreporting of symptoms. In fact, patients may intentionally over-report or exaggerate symptoms for some personal benefit; a phenomenon known as malingering.

There are many reasons why veterans may feign PTSD or exaggerate symptoms. One of the most common reasons however is financial compensation. In fact, data suggest that among veterans with PTSD in the Veterans Affairs (VA) healthcare system, 95% apply for financial compensation (Taylor et al., 2007). Data also suggest that malingering occurs in at least 20% of compensation-seeking combat veterans. Furthermore, between the years 1999-2004, PTSD disability payments increased 149% equaling up to $4.3 billion annually. This far exceeds the 42% increase in all other disability payments (Department of Veteran Affairs Office of Inspector General, 2005 as cited in Taylor et al. 2007). Economic impact aside, malingering patients can: divert valuable resources from patients with genuine PTSD, suffer negative consequences from participating in PTSD treatment, and negatively impact therapeutic alliance for other patients (Taylor et al., 2007). Ultimately, malingering disrupts many important systems within research and treatment settings and poses a major problem to healthcare systems, particularly the VA. That said, much effort has been put forth to improve the detection of genuine symptomology versus malingering.

Given all the limitations of subjective assessment of PTSD, including the deliberate attempts to manipulate scores such as to falsely present with PTSD, there is a need to examine alternative methods of PTSD diagnosis and assessment such as incorporating more objective measures of emotional response. For example, there is strong evidence that individuals with PTSD are more physiologically responsive to trauma-related stimuli than those without PTSD. Wangelin and Tuerk (2015) for example, reported that heart rate (HR) and skin conductance response (SCR) to trauma imagery was a good objective outcome measure of PTSD symptoms throughout prolonged exposure treatment. Notably, another study found physiological reactivity (i.e., HR, SCR, and electromyography) to be almost as effective at predicting PTSD in participants (whose data were collected from five other related studies) as subjective distress was (Pineles et al., 2013). This same study also concluded that physiological reactivity was significantly better at predicting the absence of PTSD than subjective distress.

In addition to physiological reactivity, the DSM-5 also outlines PTSD symptoms that reflect marked differences in cognitive function (APA, 2013). Specifically, clinical experience and the extant literature support the idea that PTSD may impair executive functioning (EF), particularly higher-level cognitive domains such as attention and inhibitory control, which in turn may make it difficult for individuals to disengage from trauma-related stimuli and emotionally regulate (Khanna 2017; Olff et al. 2014; Polak et al. 2012). Moreover, implications from multiple studies suggest that difficulty with executive function and consequently suppressing emotional response may contribute to the manifestation of other PTSD symptoms such as engaging in avoidance to minimize the emotional distress that may manifest as reexperiencing and hyperarousal (Aupperle et al., 2012). So, while PTSD may be most notably recognized by a number of marked behavioral symptoms, mounting evidence from the neurocognitive literature supports the hypothesis that these behavioral symptoms are actually reflective of underlying executive dysfunction. As such, several studies have adopted traditional cognitive measures of attentional interference such as the Stroop Task and the Visual Search Task (VST) and re-formulated them for use with clinical populations.

The Stroop Task for example, traditionally assesses attention bias by measuring response latency (i.e., the amount of time for a participant to give a vocal response) following the presentation of a color word (i.e., blue, red, green, etc.) whose font color is different than the color's name (e.g., the word *blue* could be printed in green font color) (Stroop, 1935). From this, the Emotional Stroop Task (EST) was developed for use amongst different clinical populations including individuals with PTSD. In the PTSD-Emotional Stroop paradigm, participants are presented words of different valence (e.g., positive valence = celebrate, negative = guilt, neutral = microwave, threat-related = bomb) and attention bias is again measured by response latency. Early research in this area by Foa and colleagues (1991) for example, used this measure to assess attention biases to threat-related stimuli in a sample of rape victims with PTSD, rape victims without PTSD, and healthy controls. Interestingly, this study found that rape victims with PTSD exhibited significantly longer latency of color-naming for rape-related words than general threat-related words than rape victims without PTSD. They also found that response latency for rape victims without PTSD was not significantly different from their control counterparts across all word types. Similarly, Khanna and colleagues (2017) used the EST along with magnetoencephalography (MEG) in a sample of veterans with and without PTSD. Again, they found that veterans with PTSD exhibited difficulty with attentional control and consequently emotion regulation evidenced by heightened activation in the medial temporal areas and lower activation in the prefrontal cortex (PFC) in response to trauma-related stimuli and compared to controls on the EST. In an earlier study Khanna and colleagues (2016) also observed significantly longer response times in reaction to combat related stimuli compared to neutral stimuli and compared to veterans without PTSD. Notably, regarding other clinical populations another study found longer response latency to trauma-related stimuli to be unique to individuals with PTSD in comparison to individuals with phobias and sub-clinical anxiety (Bryan & Harvey, 1997).

The Visual Search Task (VST) is another measure of attention bias that has been used to assess cognitive processes in individuals with PTSD. In the VST, participants are shown an array of figures (e.g., shapes or lines) following either threat-related or non-threat related stimuli. After which, participants are again presented with the array and asked to indicate whether or not a target stimulus that may have been present before is still present (e.g., whether a red circle is present in an array of shapes). Notably, Olatunji and colleagues (2015) found that veterans with PTSD exhibited greater response latency, indicating greater difficulty disengaging from trauma-related stimuli relative to their counterparts. That said, there are limited studies examining attention bias using the VST, and even fewer have examined whether the VST can discriminate individuals with PTSD from those without. In fact, two of the limited studies were conducted using samples of participants designated as high in PTSD or low in PTSD. These studies posited that attention bias was an effect in PTSD that could be measured using the VST (mostly based on findings from the EST/PTSD literature), and so the aim of these studies was to determine whether attentional bias in PTSD was reflective of interference (i.e., "difficulty disengaging from threat") or facilitation (i.e., "being drawn to threat") (Pineles et al., 2007; Pineles et al., 2009). Findings from these studies indicated that there was evidence for interference but not facilitation, and that veterans with High PTSD demonstrated "difficulty disengaging" to threat-relevant words relative to neutral words but veterans with Low PTSD did not demonstrate this effect. That said, this study did not include "healthy" controls. Results from these studies ultimately suggest that individuals with PTSD may have difficulty averting attentional resources from threat-related cues and thus exhibit delayed disengagement from trauma related stimuli (Olatunji et al., 2015 Pineles et al. 2007, Pineles et al. 2009). Thus, a key implication from these studies is that these tasks may be viable objective measures of PTSD but more research is needed.

With regard to other symptoms, individuals with PTSD (and other anxiety-related disorders for that matter) tend to demonstrate irregular approach and avoidance patterns. Specifically, individuals with PTSD tend to exhibit avoidance behavior to threat- or trauma-related stimuli. Cognitive measures such as the Approach Avoidance Task (AAT) can be used to measure these avoidance patterns by having participants respond to threat-related and non-threat-related images. In doing so, they are then tasked with the instruction to either pull a joystick towards or away from themselves in response to a feature of an image (e.g., orientation [i.e., landscape or portrait] or color of the border of the image). Avoidance is then measured by taking the difference between the reaction time to pull forward (approach) and push away (avoid) the stimuli. Findings from several studies using the AAT suggest that individuals with PTSD exhibit measurable avoidance behaviors that are apparent when exposed to certain stimuli (Clausen et al., 2016; Fleurkens et al., 2014; Wittekind, 2015). Again, these findings support the practicality of using the Approach-Avoidance Task in objectively measuring PTSD.

The limitations of structured interviews and self-report measures as outlined above coupled with the negative impacts of misdiagnosis on patients and the healthcare system suggest a need for an objective assessment of PTSD. Yet, despite a strong body of evidence suggesting that individual cognitive measures can objectively assess PTSD, no one such measure is infallible, as patients often report with differing symptoms patterns despite having the same diagnosis. Thus, although an objective measure may be superior to subjective measures, the use of a single objective measure may exhibit only minimal accuracy for individuals whose cognitive symptom pattern does not match the goal of the test. Thus, rather than a single test, a battery of cognitive tests (similar to batteries that are used for standard neuropsychological assessments) may enhance detection accuracy and decrease the possibility of false positives or negatives. However, to date and to our knowledge, no such battery exists (Bauer et al., 2013; Gramlich et al., 2017). Such a tool could not just improve detection of PTSD, help identify under and over reporting of symptoms, but provide additional information on patient characteristics all of which in turn could improve patient care. Moreover, the computerization of such an assessment could address resource efficiency (e.g., time and cost) and improve accessibility all while bolstering objectivity. As such, this study aims to provide preliminary support for an objective test battery for PTSD amongst combat veterans comprising the three aforementioned tasks: Emotional Stroop Task (EST), Visual Search Task (VST), and Approach-Avoidance Task (AAT). Differences across groups on individuals test variables of interest will be examined. Specific hypotheses are the following. One, veterans with PTSD will perform differently than veteran and civilian controls without PTSD across the three cognitive tasks as measured by reaction time and accuracy. Two, veterans with PTSD will react differently to combat-related stimuli compared to the positive and negative stimuli also measured by reaction time and accuracy. The findings from this study may provide preliminary evidence supporting the future development of an objective battery to identify PTSD that can be used with or as an alternative to subjective measures.

METHOD

Participants

Participants were recruited between October 2018 and July 2023 via posters, mailings at the UCF main campus, the UCF Sona System, and newspaper and digital advertisements at UCF branch campuses, in the community, and at local UCF RESTORES recruiting events involving military personnel. Additionally, participants were recruited at the Veterans of Foreign Wars of the U.S. (VFW), Veterans Memorial Center – Brevard County, and Disabled American Veterans facilities. Recruited participants could include UCF students or individuals in the community. UCF students who participated in the study and were recruited via SONA were awarded 0.50 SONA credits for every 30 minutes of face-to-face research participation time. Individuals that were either non-UCF students or UCF students who were not seeking SONA credit were compensated with a $75.00 Amazon gift card for completing the study. To determine eligibility, participants completed a brief (5 minute) phone screener. Participants who met inclusion criteria based on the phone screener then completed an in-person assessment to fully determine study eligibility and consequently group eligibility.

To meet the requirements to participate in the study, participants had to be between the ages of 26 to 65 years old, male, able to consent to participation, and be fluent in English. They also had to have no significant vision difficulties (those whose visual acuity score fell below 20/30 with the aid of contacts or glasses as determined using the Snellen Eye Chart. They could not have any form of color blindness (as determined by the Ishihara Test) and no moderate or severe TBI history (as determined by the Ohio State University TBI Identification Method – Interview Form [OSU-TBI-ID]; Corrigan & Bogner, 2007). Participants could not be taking benzodiazepine (e.g., Xanax, Valium, and Klonopin) or beta blocker (e.g., propranolol) medications, could not meet criteria for psychosis, moderate or severe substance use disorder, or antisocial personality disorder (as determined by the Mini International Neuropsychiatric Interview for DSM-5 version 7.0.2 [MINI]; Sheehan et al., 1997), and could not have active suicidal intent or a plan. Finally, individuals had to consent to being audio recorded during the in-person assessment; those who did not were excluded from the study. Based on results from these assessments, participants were placed in one of three groups. The first group consisted of combat veterans with PTSD (PTSD+), the second, nonmilitary personnel who also did not meet criteria for PTSD (CV), and finally group three consisted of veterans who did not meet criteria for PTSD (PTSD-).

Demographics

Among the 81 participants (N = 81), six were missing demographic data. Participant age ranged from 26 to 59 with the majority of participants being in middle adulthood (*M* = 37.36, *SD* = 8.11). Over half of the participants reported being married (60%). The remaining participants either reported being single (28%), divorced (6.7%), or separated (4%). Regarding race/ethnicity, two-thirds of the participants indicated that they were White (66.2%), followed by Black or African American (12.2%), Hispanic or Latino (8.1%), Asian (8.1%), and (5.4%) chose to report themselves as "Other." Lastly, no one indicated that they were American Indian or Alaska Native (0%), and Native Hawaiian or Other Pacific Islander (0%).

A one-way analysis of variance (ANOVA) indicated that there was a significant difference in age across the three groups $F(2,72) = 6.52$, $p < .05$. A Tukey post-hoc analyses indicated that participants in group two (i.e., civilians [*n* = 16, *M* = 31.31, *SD* = 4.77]) were significantly younger -7.9, 95% CI [-13.58, -2.23] than group one (i.e., veterans with PTSD [*n* = 28, *M* = 39.21, *SD* = 8.57]), and also significantly younger -7.4, 95% CI [-13.07, -1.92] than group three (i.e., veterans without PTSD [*n* = 31, *M* = 38.81, *SD* = 7.74]). To determine whether this difference affected the dependent variables, Pearson correlations were run between age and reaction time, and age and accuracy. Of these twenty-four correlations, three were statistically significant. First, there were small positive correlations between age and accuracy scores in the positive condition with the set size of 12, $r = .31$ and set size of 24, $r = .25$ on the Visual Search Task (VST). Second, there was a small positive correlation between age and accuracy scores, again in the positive condition $r = .25$ on the EST. However, though these were statistically significant, they were considerably weak correlations. Because the majority of the correlations were not significant, the decision was made to not control for age in the main analyses.

On a final note, a t-Test was conducted to determine that the veteran with PTSD group was significantly different from the veteran without PTSD group on the CAPS-5. Results were significant $t(49.19) = 11.66$, $p < .001$ indicating that the veterans with PTSD group (*M* = 37.76 *SD* = 11.81) did in fact have significantly higher CAPS-5 severity scores compared to the veterans without PTSD group (*M* = 7.94, *SD* = 7.33).

Materials

Assessment Measures

MINI International Neuropsychiatric Interview

The *Mini International Neuropsychiatric Interview version 7.0.2 for DSM-5* (MINI; Sheehan et al., 1997) is a brief, structured interview that is used to determine the presence of 17 common DSM-5 psychiatric diagnoses including anxiety-related disorders, mood disorders, substance use disorders, and antisocial personality disorder. Typical duration of administration is relatively short (about 10-15 minutes). Psychometrics are not available for the recent version of the MINI for DSM-5. However, previous versions of the MINI have shown good reliability and diagnostic utility, and given the minimal format revisions from prior versions, few psychometric differences are assumed.

Clinician-Administered PTSD Scale (CAPS-5)

The CAPS-5 is a semi-structured interview that assesses for the absence or presence and overall severity of PTSD (Weathers et al., 2013). It contains 30-items that include questions regarding: intensity and frequency of the 20 DSM-5 PTSD symptoms, onset and duration of symptoms, subjective distress, areas of impairment, rating validity, improvement, and severity. The CAPS-5 has demonstrated excellent psychometric properties with strong inter-rater reliability (κ = .78 to 1.00) and test-retest reliability (κ = .83), as well as high internal consistency (α = .88) for the CAPS-5 total severity score (Weathers et al., 2017). Additionally, the CAPS-5 has good convergent validity with the CAPS for DSM-IV (r = .83) and PTSD Checklist for DSM-5 (r = .66) as well as good discriminant validity with measures of anxiety, depression, psychopathy, alcohol abuse, and somatization (r = .02 to .54; Weathers et al., 2017).

Self-Report Measures

Participants also completed several self-report measures. See Appendix for descriptions.

Cognitive Tasks

Participants completed the three cognitive tasks presented on a 17.3-inch ASUS laptop using E-prime 2.0, a psychology programming software.

Emotional Stroop Task (EST)

For this task, participants were asked to identify the font color (red, blue, green, and yellow) of the presented word displayed on the computer screen by pressing a key on a keyboard that corresponded to the font color (e.g., red, blue, green, and yellow stickers were placed the corresponding key). The present study modified the Emotional Stroop Task with inclusion of combat-related words in addition to neutral, negative, and positive valanced ones. Combat-related and neutral valanced words were selected from a standardized word list used in a previous study by Ashley and colleagues (2013) while positive and negative words were selected from the Affective Norms for English Words normative database (Bradley & Lang, 1999). Consistent with methodology used by Khanna and colleagues (2016), the words between each category were matched based on number of letters, frequency, orthographic neighborhood size, phonological neighborhood size, average naming latency, average naming accuracy, average lexical decision time, and average lexical decision accuracy.

Participants first completed a 40-item practice trial with colored letters (not repeated in subsequent trials) so as to gain familiarity with the task and ensure that the task was understood. After the practice trial, participants completed four more, valance-specific trials (positive, negative, neutral, and combat-related), each containing 54-words. Each section of 54-words was followed by a 15- to 30-second break to prevent fatigue. At the start of each trial (including the practice one), participants were presented the following instructions: "Respond to the ink color of the word as quickly and accurately as possible" (Bar-Haim et al., 2016). Participants then saw a black fixation cross on a gray background on the center of the screen for .5 seconds which was followed by the presentation of the colored word also on a gray background. Per the instructions, participants then had to select the correct key that corresponded with the color of the word. In total this task took about 10 minutes to complete.

Visual Search Task (VST)

In this task, participants scan an array of 12 and 24 red and green colored forward- and back-slashes for the presence of a red forward slash. They are then asked to indicate the presence or absence of the target (i.e., red forward slash) in the array by pressing a corresponding key. To adapt the task to the PTSD paradigm, participants were first presented with a white fixation cross in the center of the screen on a black background. After .5 seconds, a positive, negative, control (i.e., gray-colored blank image), or combat-related image appeared for 1 second before disappearing. Participants were then presented with an identical fixation cross for .5 seconds followed by either a 12 or 24-item array of forward and backslashes from which participants were to indicate whether or not a red forward slash was present in the array. This task began with 24 practice trials on the control conditions to ensure participants understood the task. Following the presentation of 80 stimuli, participants were offered an optional break. Excluding practice trials, there were a total of 320 stimuli. This task took approximately 30 minutes to complete.

Approach Avoidance Task (AAT)

This task required participants to successfully pull forward or push away a joystick based on the orientation (i.e., landscape or portrait) of each presented image. Participants were presented a total of 256 stimuli presented in four sections of 64 stimuli to reduce fatigue. These four sections of 64 stimuli were further evenly divided among four different image-types: positive, negative, control (i.e., gray-colored blank image), and combat-related images (16 images per group). Prior to the presentation of 256 total stimuli, participants were presented 10 practice trials on control images. At the start of each trial, participants were presented with a fixation cross for .5 seconds, immediately followed by a landscape or portrait oriented image for which they needed to either pull forward or push away using the joystick. The positive and negative valanced images were exported from the International Affective Picture System (IAPS; Lang, Bradley, & Cuthbert, 2008), a database that provides standardized pictures for studying emotion and attention. The combat-related images were exported from the Military Affective

Picture System (MAPS; Goodman et al., 2016), a database that provides standardized combat-related pictures for studying emotion and attention. This task took approximately 25 minutes to complete.

Procedure

Participants completed this study at two time points. The first was the telephone screening interview where participants were initially contacted by a study clinician to determine eligibility for the study. The second time point was the in-person assessment. Upon arriving at a UCF RESTORES facility, participants reviewed the informed consent form with a study clinician. Then, those who consented completed the Demographics Questionnaire and Medication Log and were assessed using the Snellen Vision Test and the Ishihara test. Next, a mental health clinician assessed participants using the Ohio State University TBI Identification Method (OSU TBI-ID; Corrigan & Bogner, 2007), the Clinician-Administered PTSD Scale for DSM-5 (CAPS-5; Weathers et al., 2013) and Mini International Neuropsychiatric Interview version 7.0.2 for DSM-5 (MINI; Sheehan et al., 1997). If full eligibility criteria were met, participants were then provided with instructions for completing the three cognitive tasks and stimulus rating forms (Emotional Stroop Task, Visual Search Task, and Approach-Avoidance Task).

Study Design

This study utilized a quasi-experimental design where three groups of participants were included: (1) veterans with combat-related PTSD; (2) nonmilitary personnel without PTSD; (3) veterans without PTSD. GPower software version 3.1 (Faul et al., 2007) was used to determine the sample size needed for a medium effect size. Power was set to 0.80 as recommended by Cohen (1992). For a power $(1-\beta) = 0.80$, $\alpha = 0.05$, it was determined that 81 total participants were needed. Due to the COVID-19 pandemic, data collection was halted for a year but resumed following the University's re-opening after the pandemic.

RESULTS

Primary analyses were examined using IBM SPSS version 23. Repeated measures ANCOVAs were conducted to assess between- and within-subjects differences in reaction times (RTs) and accuracy scores (ACC) across groups and conditions (i.e., stimuli type [i.e., combat, negative, and positive) while controlling for baseline performance (using the neutral condition) within each of the cognitive tasks. Unless otherwise noted, assumptions of sphericity were not violated (using Mauchly's Test of Sphericity).

Emotional Stroop Task (EST)

Accuracy

The results of the ANCOVA revealed that there were no significant main effects for group or condition. Additionally, there was no significant interaction effect for group x condition.

Reaction Time

The ANCOVA revealed a statistically significant main effect for condition $F(2, 152) = 7.32$, $p < .001$, partial $\eta^2 = .088$. Post hoc analyses with Sidak adjustments indicated that there was a significant mean difference of 36.39 milliseconds (ms), 95% CI [10.55,62.23], $p < .05$ between the combat condition and positive condition with reaction times longer in the combat condition $M = 778.61$ms ($SE = 8.07$) compared to the positive condition $M = 742.22$ms ($SE = 10.58$). The reaction times in the negative condition did not differ significantly from either of the other two conditions.

Additionally, there was a significant main effect for group $F(2, 76) = 3.86$, $p < .05$, partial $\eta^2 = .092$. Post hoc analyses revealed a significant mean difference in reaction times of 53.19ms, 95% CI [6.36,100.02], $p < .05$ between the veterans with PTSD group and the civilian group, indicating that veterans with PTSD had overall longer reaction times *M* = 784.03ms (*SE* = 12.38) compared to civilians *M* = 730.84ms (*SE* = 14.43). The reaction times of veterans without PTSD were not significantly different from either of the other two groups.

Visual Search Task (VST)

Data were analyzed separately by the set size of the task (i.e., 12 slashes presented, and 24 slashes presented) as well as whether or not the target was absent or present.

Target Present

Accuracy (Set Size 12)

The results of the ANCOVA indicated a statistically significant main effect for group $F(2, 75) = 3.32$, $p < .05$, partial $\eta^2 = .081$. Pairwise comparisons in the post hoc analysis with Sidak adjustments found a significant mean difference of 2%, 95% CI [-.05, .00], $p < .05$ indicating that the veterans with PTSD had a lower mean accuracy score 95% accuracy (*SE* = .01) than veterans without PTSD 98% accuracy (*SE* = .01). The score 96% accuracy (*SE* = .01). of the civilian group was not statistically different from either of the veteran groups.

Reaction Time (Set Size 12)

For the ANCOVA examining reaction time, Mauchly's test of sphericity was significant $x^2(2) = 10.34$, $p < .05$. As this suggests that the assumption of sphericity was violated, Greenhouse-Geisser corrected tests are used for examination of statistical significance. The ANCOVA revealed a statistically significant main effect for condition $F(1.77, 132.69) = 3.66$, $p < .05$, partial $\eta^2 = .047$ indicating that there was a significant difference in the RTs across conditions. That said, Sidak adjusted pairwise comparisons did not demonstrate statistically significant differences in the means for condition.

Accuracy (Set Size 24)

The ANCOVA results did not reveal any significant main effects for condition or the two-way interaction. There was a significant main effect for group $F(2, 75) = 3.22$, $p < .05$, partial $\eta^2 = .079$. However, pairwise comparisons found no significant differences between the groups.

Reaction Time (Set Size 24)

There were no main effects for reaction time with respect to condition or group, nor was there a significant two-way interaction.

Target Absent

Accuracy (Set Size 12)

There were no main effects with respect to condition or group, nor was there a significant two-way interaction.

Reaction Time (Set Size 12)

There were no main effects with respect to condition or group, nor was there a significant two-way interaction.

Accuracy (Set Size 24)

There were no main effects with respect to condition or group, nor was there a significant two-way interaction.

Reaction Time (Set Size 24)

The ANOVA did not reveal any significant main effects for group or condition. That said, there was a significant two-way interaction of group by condition $F(4, ***) = 3.40$, $p < .05$, partial $\eta^2 = .083$. Post hoc analyses were conducted using Sidak adjustments. Pairwise comparisons for the significant two-way interaction indicated that veterans with PTSD were significantly slower 166.71ms, 95% CI [46.38, 287.04], $p < .05$ in the combat condition 2391.37ms (*SE* = 46.97) compared to the negative 2224.66ms (*SE* = 38.35) and positive 2234.09ms (*SE* = 41.19) conditions. Additional pairwise comparisons indicated that veterans without PTSD were significantly slower 120.72ms, 95% CI [.57, 240.87], $p < .05$ in the combat condition 2354.26ms (*SE* = 46.89) compared to the negative condition 2337.87ms (*SE* = 41.13).

Approach Avoidance Task (AAT)

Accuracy

There was a significant main effect of condition $F(2, 150) = 8.19$, $p < .001$, partial $\eta^2 = .098$. However, Sidak adjusted pairwise comparisons did not identify significant mean differences for condition. There was no main effect for group and a three-way interaction between group x movement (push vs. pull) x condition was not significant.

Reaction Time

There was a significant main effect for group $F(2, 75) = 4.14$, $p < .05$, partial $\eta^2 = .099$. Pairwise comparisons indicated that there was a significant mean difference of 72.85ms, 95% CI [8.28,137.41], $p < .05$ between the veterans without PTSD 2159.89ms (*SE* = 16.88) and the civilians 2087.05ms (*SE* = 20.30) indicating that the veteran group were slower on the AAT compared to the civilian group across the conditions, whereas the mean score for the veterans with PTSD fell between.

Mauchly's test of sphericity was significant $x^2(2) = 14.24$, $p < .001$. As the assumption of sphericity was violated, the significant two-way interaction of condition by group $F(3.40, 127.66) = 2.94$, $p < .05$, partial $\eta^2 = .073$ was interpreted using the Greenhouse-Geisser correction. Post hoc analyses were again conducted using Sidak adjustments. Pairwise comparisons for the significant two-way interaction indicated that reaction times were longer in the combat condition 2172.49ms (*SE* = 21.80) compared to the negative condition 2135.22ms (*SE* = 18.98) in the veterans with PTSD group 37.26ms, 95% CI [.57,73.96], $p < .05$. Pairwise comparisons of the two-way interaction also indicated that there was a significant mean difference 109.63ms, 95% CI [27.82,191.46], $p < .05$ between the veterans with PTSD group 2172.49ms (*SE* = 21.80) and civilian group 2062.85ms (*SE* = 28.27) in the combat condition in that veterans with PTSD were significantly slower to react than their civilian counterparts. There was also a significant mean difference of 84.90ms, 95% CI [4.52,165.26], $p < .05$ in the combat condition between the veterans without PTSD 2147.75ms (*SE* = 21.02) and civilian groups 2062.85ms (*SE* = 25.27), with the veterans and without PTSD also exhibiting slower reaction times compared to civilians. Lastly, the three-way interaction (i.e., group x movement x condition) to measure approach-avoidance tendencies was not significant.

DISCUSSION

This study assessed cognitive functioning in veterans with PTSD using three cognitive tasks [the Emotional Stroop Task (EST), the Visual Search Task (VST), and the Approach Avoidance Task (AAT)]. Although other investigations have assessed performance on these tasks individually, to our knowledge, this is the first investigation that has used a series of tasks to more fully assess potential cognitive impairment in veterans with PTSD when compared to combat veterans without PTSD and civilians without PTSD and no history of combat trauma. The results suggest the presence of both general and specific cognitive slowing/attention bias that may be related to PTSD.

Emotional Stroop Task (EST)

The results of the EST revealed that veterans with PTSD were slower to react across all the conditions compared to the civilian group. Contrary to our hypothesis, the two-way interaction (group x condition) was not statistically significant indicating that veterans with PTSD did not perform worse than the other groups in the combat condition compared to the other conditions. In general, these findings might suggest a cognitive slowing in individuals with PTSD, which may be a result of their hyperarousal and inability to focus. Our results are consistent with a meta-analysis conducted by Cisler and colleagues (2011), which found impaired performance in the PTSD groups (compared to a non-trauma exposed control group) when presented with PTSD-relevant stimuli, and generally threatening stimuli. Also consistent with the meta-analysis, this investigation did not find group difference in performance between the PTSD group and the trauma exposed but no PTSD group. Cisler and colleagues (2011) argue that these findings may be evidence for lack of EST effect (i.e., slower reaction times) for individuals with PTSD for trauma-specific stimuli and instead may be indicative of an overall negative impact on cognition processes regardless of stimuli type. Also worth noting, moderator analyses from Cisler and colleagues (2011) also found that significant EST effects (i.e., slower reaction times) were more evident when blocked designs and unmasked stimuli were used (as opposed to randomized designs and masked stimuli), as was the case in this investigation.

Visual Search Task (VST)

The VST analysis examined accuracy and reaction time separately according to set size and target presence. That is, whether the VST itself had 12 or 24 slashes in the task for participants to search through to find and determine whether or not the target was absent or present. That said, for the analyses concerning accuracy scores and reaction times in the target present analyses, there were no significant main effects nor was there a significant two-way interaction in the set size of 24 with the exception of the analysis concerning accuracy which had a significant main effect of group. That said, pairwise comparisons found no significant differences between the groups. Regarding the analysis for the 12 set, veterans with PTSD had lower accuracy scores across the conditions compared to veterans without PTSD. Again, particularly as it relates to our hypotheses, there was not a significant two-way interaction between group x condition in any of the analyses concerning accuracy scores and reaction times in the VST. In terms of the analyses concerning accuracy scores and reaction times in the target absent conditions, there was a significant two-way interaction for reaction times in the set size of 24 which suggested that veterans with PTSD were significantly slower on the combat condition compared to the negative and positive conditions. That said, veterans without PTSD were also significantly slower in combat condition compared to the negative condition but not the positive condition.

As discussed in the introduction, there is limited research on attention bias in PTSD as measured by slower reaction times on the VST. Within this limited literature, two studies used participants designated as high in PTSD or low in PTSD (Pineles 2007, 2009). Findings indicated that veterans with High PTSD demonstrated “difficulty disengaging” to threat-relevant words relative to neutral words but veterans with Low PTSD did not demonstrate this effect. So, although these studies conclude that the Visual Search Task demonstrates attention bias in PTSD in the form of interference, deficits were found only in individuals with severe symptomatology. Therefore, it is inaccurate to conclude, at this time, that they are distinctive of everyone with this diagnosis. Of additional note, differences in the assessment measures used precludes our ability to compare severity in our sample and the studies by Pineles (2007, 2009), as they used the PCL-M, whereas we used the CAPS-5. Such a comparison may have been helpful to determine if our sample had lower levels of severity which may help explain the overall lack of significant findings. Of final note, as there are few studies utilizing the VST to measure attention bias in PTSD, much of the theoretical foundation cited in the few Visual Search/PTSD studies are rooted in the findings from the Emotional Stroop/PTSD literature. Considering the EST is plagued by issues of publication bias against negative findings, lack of specificity, and less significant findings in studies with less emotionally salient stimuli (i.e., studies with randomized and masked designs), it may be worth considering whether similar limitations exist in using the Visual Search Task (Cisler, 2011; Kimble et al., 2009). If so, our Visual Search Task employed a randomized design which may also explain the general lack of significant findings.

Regarding the significant two-way interaction, this finding did support our hypotheses that veterans with PTSD would be slower in the combat condition compared to the negative and positive conditions. However, it is worth noting veterans without PTSD were also significantly slower in the combat condition compared to the negative condition. As suggested earlier, this may be reflective of an overall negative impact following exposure to combat or trauma exposure and not necessarily an effect of PTSD.

Approach Avoidance Task (AAT)

In the AAT, veterans without PTSD were significantly slower in responding to the stimuli than civilian controls across all conditions. Interestingly, the AAT was the only task to result in a significant two-way interaction. In line with our hypotheses, veterans with PTSD had slower reaction times compared to the civilian controls in the combat condition. Additionally, veterans without PTSD were also significantly slower than the civilian controls in the combat condition. That said, there was not a significant difference in reaction times between veterans with PTSD and without PTSD. Ultimately, findings from this task appear capable of distinguishing individuals with combat exposure from those without such exposure.

Again, our study demonstrated slower reaction times amongst combat veterans in response to combat-related stimuli compared to civilian controls but not veteran controls. In one regard, this may reflect findings from Cisler et al. (2011) that suggest that these cognitive tasks may be capturing a general negative effect of trauma exposure but not a distinct dysfunction in attentional control resulting from PTSD psychopathology. In another, this may demonstrate the role that personal relevance plays in participants' reaction times. This will be discussed further below.

General Discussion

Across the three tasks, participants with PTSD displayed cognitive impairments, although the specific deficits were not consistent. As such, these tasks were able to capture different ways in which veterans with PTSD performed worse than either of the control groups. One purpose of this study was to examine the potential of these tasks to provide an objective assessment system for PTSD. Although the study revealed several statistical differences, there was only one variable in one task that distinguished veterans with PTSD from veterans and without PTSD. Given the range of individual differences in veterans with PTSD, it may be that no one individual task can objectively differentiate these two groups. One alternative may be to combine scores from various tasks to provide a more robust variable that may capture these more subtle individual differences.

Another consideration is the personal relevance of the stimuli that we used in this investigation. Given our extensive experience with the treatment of PTSD, the words were selected based on combat events that are commonly reported by patients in the UCF RESTORES clinic. However, whether or not these events were personally relevant for each of the participants in this investigation is not known. A study by Williams and colleagues (1996) concluded that personally relevant words may elicit longer reaction times in the Stroop Task. Another study by Gramlich (2019), found neuropsychological evidence for this theory. Specifically, they utilized Functional near-infrared spectroscopy (fNIRS) to measure neurological reactions to trauma-related cues (e.g., sounds and odors) in a sample of combat veterans with and without PTSD. Interestingly, they found that the odors with greater similarity to the veteran with PTSD participants' combat-experiences altered their neurological response, in other words, odors with greater personal relevance led to significant increases in brain activation. Considering this, it may be possible that performance on tasks like the EST, VST, and AAT may be affected by personal relevance, and instances of significantly longer reaction times may be reflective of greater personal relevance. On the other hand, insignificant results may be reflective of the fact that the combat-related stimuli do not have great enough similarity to the participant's traumatic experience to elicit altered responses. As such, future studies may need to use stimuli specific to the trauma that resulted in the emergence of PTSD. Finally, it may be worth considering whether these tasks may be more powerful when coupled with other types of objective measures such as heart rate, skin conductance, or perhaps even eye-tracking. While this may complicate the assessment process and thus may not be appropriate in most cases, it may be worth considering in difficult cases such as instances where the patient is suspected of malingering.

This study is not without limitation. Particularly, the COVID-19 pandemic halted data collection and consequently progress on the present study. Though the majority of the data were collected pre-COVID and there were not any significant changes in protocol or standard operating procedures, the experience of a global pandemic may have impacted the study in unforeseeable ways. Also worth considering, this study utilized ANCOVAs to control for the neutral condition. This however, is not consistent with the analytic strategy of other studies examining the effect that a DSM-5 diagnoses have on cognitive task performance. As such, this may explain some of the inconsistencies in our findings from the extant literature.

CONCLUSION

This was the first study to examine a combination of computer-based cognitive tasks to assess and discriminate combat-related PTSD. Findings from this study coupled with the extant literature provide preliminary support for the hypothesis that a battery of cognitive tasks may be an effective tool for objectively measuring PTSD. That said, this study and the extant literature also suggest that there may be methodological ways to improve the sensitivity of these tasks. As this was the first study of its kind to our present knowledge, much work is still warranted before a cognitive battery of tasks for PTSD can be feasibly utilized in clinical practice.

APPENDIX A: TABLES

Table 1: Demographic Characteristics of Participants

	Group					
	Total	PTSD+	CV	PTSD-		
	M(SD) or n(%)	M(SD) or n(%)	M(SD) or n(%)	M(SD) or n(%)	F(p)	T(p)
Age	37.36(8.11)	39.31(8.57)	31.31(4.77)	38.81(7.74)	6.52*	
Marital Status						
Married	45(60.0%)	17(60.7)	5(31.3%)	23(76.7%)		
Single	21(28.0%)	6(21.4)	11(68.8%)	4(13.3%)		
Divorced	5(6.7%)	3(10.7)	0(0%)	2(6.7%)		
Separated	3(4.0%)	2(7.1)	0(0%)	1(3.3%)		
Race/Ethnicity						
White	49(66.2%)	20(71.4)	9(56.3%)	20(66.7%)		
Black or African American	9(12.2%)	2(7.1)	0(0%)	7(23.3%)		
Hispanic/Latino	6(8.1%)	4(14.3)	1(6.3%)	1(3.3%)		
Asian	6(8.1%)		5(31.3%)	1(3.3%)		
American Indian or Alaska Native	0(0%)		0(0%)	0(0%)		
Native Hawaiian or Other Pacific Islander	0(0%)		0(0%)	0(0%)		
Other	4(5.4%)	2(7.1%)	1(6.3%)	1(3.3%)		
CAPS-5		37.76(11.81)		7.94(7.33)		11.84***

Note. *p<.05, **p<.01, ***p<.001

Table 2: Emotional Stroop Task

Accuracy	Group				
	PTSD+	CV	PTSD-		
	M(SD)	M(SD)	M(SD)	F(p)	η2
Condition				2.15	0.03
Combat	.98(.03)	.97(.03)	.98(.03)		
Negative	.99(.02)	.97(.03)	.98(.03)		
Positive	.98(.02)	.97(.03)	.98(.03)		
Group				3.06	0.07
Condition x Group				0.97	0.03
Reaction Time	**Group**				
	PTSD+	CV	PTSD-		
	M(SD)	M(SD)	M(SD)	F(p)	η2
Condition				6.84**	0.15
Combat	863.97(239.31)	706.85(141.68)	756.15(113.98)		
Negative	816.73(216.15)	697.19(173.97)	750.19(116.56)		
Positive	788.86(148.07)	696.57(186.35)	734.84(117.16)		
Group				3.86*	0.09
Condition x Group				1.05	0.03

*p<.05, **p<.01, ***p<.001

Table 3: Visual Search Task Target Present Set Size 12

Accuracy 12	Group				
	PTSD+ M(SD)	CV M(SD)	PTSD- M(SD)	F(p)	η2
Condition				1.16	0.02
Combat	.94(.09)	.97(.03)	.98(.03)		
Negative	.96(.05)	.96(.04)	.97(.04)		
Positive	.96(.05)	.95(.06)	.98(.03)		
Group				3.32*	0.08
Condition x Group				2.53	0.06

Reaction Time 12	Group				
	PTSD+ M(SD)	CV M(SD)	PTSD- M(SD)	F(p)	η2
Condition				3.66*	0.05
Combat	1249.62(384.63)	1194.14(416.65)	1242.07(382.56)		
Negative	1288.47(405.13)	1222.39(398.89)	1262.99(319.35)		
Positive	1249.60(369.61)	1175.93(352.10)	1288.61(380.32)		
Group				1.72	0.04
Condition x Group				1.21	0.03

*p<.05, **p<.01, ***p<.001

Table 4: Visual Search Task Target Present Set Size 24

Accuracy 24	Group				
	PTSD+ M(SD)	CV M(SD)	PTSD- M(SD)	F(p)	η2
Condition				2.58	0.03
Combat	.90(.09)	.93(.08)	.95(.05)		
Negative	.92(.09)	.93(.08)	.96(.05)		
Positive	.94(.07)	.94(.06)	.97(.04)		
Group				3.22*	0.08
Condition x Group				0.47	0.01

Reaction Time 24	Group				
	PTSD+ M(SD)	CV M(SD)	PTSD- M(SD)	F(p)	η2
Condition				2.54	0.03
Combat	1547.33(493.74)	1445.35(573.40)	1513.50(446.06)		
Negative	1469.36(408.75)	1438.57(521.19)	1516.08(436.79)		
Positive	1481.22(543.30)	1459.36(601.51)	1461.21(407.92)		
Group				0.84	0.02
Condition x Group				0.92	0.02

*p<.05, **p<.01, ***p<.001

Table 5: Visual Search Task Target Absent Set Size 12

Accuracy 12	Group				
	PTSD+ M(SD)	CV M(SD)	PTSD- M(SD)	F(p)	η2
Condition				1.88	0.02
Combat	0.99(.02)	1.00(.02)	1.00(.01)		
Negative	.99(.03)	.99(.02)	.99(.02)		
Positive	.99(.03)	.99(.02)	.99(.03)		
Group				0.81	0.02
Condition x Group				0.36	0.01

Reaction Time 12	Group				
	PTSD+ M(SD)	CV M(SD)	PTSD- M(SD)	F(p)	η2
Condition				0.03	0
Combat	1506.52(699.59)	1378.57(504.79)	1480.85(459.90)		
Negative	1567.60(724.67)	1428.52(519.43)	1527.09(451.79)		
Positive	1618.63(749.13)	1503.40(593.15)	1554.38(454.50)		
Group				0.21	0.01
Condition x Group				0.39	0.01

*p<.05, **p<.01, ***p<.001

Table 6: Visual Search Task Target Absent Set Size 24

Accuracy 24	Group				
	PTSD+ M(SD)	CV M(SD)	PTSD- M(SD)	F(p)	η2
Condition				0.12	0
Combat	.98(.03)	.99(.02)	.99(.02)		
Negative	.99(.02)	1.00(.02)	.98(.03)		
Positive	.99(.01)	.99(.02)	.99(.02)		
Group				0.54	0.01
Condition x Group				1.46	0.04

Reaction Time 24	Group				
	PTSD+ M(SD)	CV M(SD)	PTSD- M(SD)	F(p)	η2
Condition				0.8	0.01
Combat	2479.14(1228.36)	2134.92(825.30)	2379.15(783.63)		
Negative	2310.52(1228.12)	2182.11(896.54)	2257.89(604.53)		
Positive	2323.11(1232.37)	2128.30(815.45)	2363.12(804.13)		
Group				0.16	0
Condition x Group				3.40*	0.08

*p<.05, **p<.01, ***p<.001

Table 7: Approach Avoidance Task

Accuracy	Group				
	PTSD+ M(SD)	CV M(SD)	PTSD- M(SD)	F(p)	η2
Condition				8.19***	0.1
Combat	.98(.04)	.99(.01)	.99(.01)		
Negative	.99(.02)	.99(.02)	.99(.01)		
Positive	.98(.03)	.99(.01)	.98(.03)		
Group				0.94	0.03
Condition x Group				0.3	0.01
MovementxConditionxGroup				0.13	0

Reaction Time	Group				
	PTSD+ M(SD)	CV M(SD)	PTSD- M(SD)	F(p)	η2
Condition				1.91	0.03
Combat	2208.51(281.26)	1997.44(467.94)	2159.91(251.13)		
Negative	2173.76(246.63)	2024.23(526.79)	2182.70(260.76)		
Positive	2174.98(262.27)	2036.54(492.37)	2174.80(259.08		
Group				4.14*	0.1
Condition x Group				2.94*	0.07
MovementxConditionxGroup				0.35	0.03

*p<.05, **p<.01, ***p<.001

APPENDIX B: ADDITIONAL MATERIALS

Self-Report Measures:

Participants completed the following self-report measures:

Demographic Information Questionnaire

The *Demographic Information Questionnaire* is a one-page form that each participant completed before testing. The demographic questionnaire gathers general information (e.g., marital status, race, education) as well as additional questions specific to veterans such as branch of service, discharge status, location of deployment, and current percentage of service-connected disability.

Medication Log

The *Medication Log* is a one-page form used to document current medication usage by asking about medication type, dosage, duration, and most recent time of use.

Clinician-Administered Measures:

Ohio State University TBI Identification Method

The *Ohio State University TBI Identification Method* (OSU-TBI-ID); Corrigan & Bogner, 2007) was used to assess previous history of head or neck injury. Specifically, this form asks for the duration of loss of consciousness and the occurrence of posttraumatic amnesia immediately after the injury. Ultimately, this form helps classify probable severity of traumatic brain injury (i.e., mild, moderate, or severe). Typical duration of administration is relatively short (approximately 3 to 5 minutes).

Snellen Eye Chart

Visual acuity was measured using the *Snellen Eye Chart*. The Snellen eye chart is a widely used estimate of visual acuity that contains eleven rows of random letters that are arranged in descending size. Participants stand 20 feet away from the chart and are asked to read the letters aloud. Visual acuity was determined by the smallest row that can be read accurately with each eye.

Ishihara Test

The *Ishihara Test* is a perception test used to briefly and accurately screen for color blindness through red-green color deficiencies. As such, participants view a series of plates that contain a randomized array of circles of various sizes and colors. Within each array, there is a pattern of dots that form a number or shape that is visible to individuals with normal red/green color vision. Participants must be able to accurately identify the number or shape presented on each array.

APPENDIX C: IRB APPROVAL LETTER

UNIVERSITY OF CENTRAL FLORIDA

Institutional Review Board
FWA00000351
IRB00001138Office of Research
12201 Research Parkway
Orlando, FL 32826-3246

APPROVAL

April 19, 2019

Dear Deborah Beidel:

On 4/19/2019, the IRB reviewed the following submission:

Type of Review:	Modification
Title:	Development of an Objective Battery for PTSD
Investigator:	Deborah Beidel
IRB ID:	MOD00000153
Funding:	None
Grant ID:	None
IND, IDE, or HDE:	None
Documents Reviewed:	• VA Flyer_Team Flyer.pdf, Category: Recruitment Materials; • Protocol.docx, Category: IRB Protocol; • Consent_PTSD TEST_Final.pdf, Category: Consent Form; • Computer Attention Study_UCF RESTORES.pdf, Category: Recruitment Materials; • Trifold PTSD Test flyer.docx, Category: Recruitment Materials; • CAPS-5.pdf, Category: Interview / Focus Questions; • Combat Exposure Scale.pdf, Category: Survey / Questionnaire; • Demographic Information Questionnaire_Final.docx, Category: Survey / Questionnaire; • Medication Log_Final.docx, Category: Survey / Questionnaire; • TLEQ_Final.doc, Category: Survey / Questionnaire; • PHQ-9.pdf, Category: Survey / Questionnaire; • MINI 7.0.2 Standard.pdf, Category: Interview / Focus Questions; • Add on to the clinic phone screen.docx, Category: Other; • Ishihara Test.PNG, Category: Test Instruments; • Snellen Vision Test.PNG, Category: Test Instruments; • Cognitive Task Screen Shots.docx, Category: Test

	Instruments; • PTSD Test Ratings_Psychometrics.docx, Category: Survey / Questionnaire; • Telephone Screen_PTSD Test_Final_v2.doc, Category: Interview / Focus Questions; • Facebook video ad for study.docx, Category: Recruitment Materials; • Flyer_Nonmilitary_v3.pdf, Category: Recruitment Materials; • OSU TBI ID.pdf, Category: Interview / Focus Questions;

The IRB approved the protocol from 4/19/2019 to 9/6/2019.

In conducting this protocol, you are required to follow the requirements listed in the Investigator Manual (HRP-103), which can be found by navigating to the IRB Library within the IRB system.

If you have any questions, please contact the UCF IRB at 407-823-2901 or irb@ucf.edu. Please include your project title and IRB number in all correspondence with this office.

Sincerely,

Gillian Morien
Designated Reviewer

Good afternoon Kathryn
This email serves as confirmation that your thesis research is connected to this IRB approval."

Deborah Beidel

Deborah C. Beidel, Ph.D., ABPP
Trustee Chair and Pegasus Professor of Psychology and Medical Education
Executive Director, UCF RESTORES
Suite 203, Building 99
University of Central Florida
4111 Pictor Lane
Orlando, FL 32816
www.ucfrestores.com

REFERENCES

American Psychiatric Association. (2013). *Diagnostic and statistical manual of mental disorders* (5th ed.). https://doi.org/10.1176/appi.books.9780890425596

Ashley, V., Honzel, N., Larsen, J., Justus, T., & Swick, D. (2013). Attentional bias for trauma-related words: Exaggerated emotional Stroop effect in Afghanistan and Iraq war veterans with PTSD. *BMC Psychiatry*, *13*(1), 86. https://doi.org/10.1186/1471-244X-13-86

Aupperle, R. L., Melrose, A. J., Stein, M. B., & Paulus, M. P. (2012). Executive function and PTSD: Disengaging from trauma. *Neuropharmacology*, *62*(2), 686–694.

Barlow, D. H. (Ed.). (2021). *Clinical handbook of psychological disorders: A step-by step treatment manual* (Sixth edition). The Guilford Press.

Bauer, M. R., Ruef, A. M., Pineles, S. L., Japuntich, S. J., Macklin, M. L., Lasko, N. B., & Orr, S. P. (2013). Psychophysiological assessment of PTSD: A potential research domain criteria construct. *Psychological Assessment*, *25*(3), 1037–1043. https://doi.org/10.1037/a0033432

Ben-Haim, M. S., Williams, P., Howard, Z., Mama, Y., Eidels, A., & Algom, D. (2016). The Emotional Stroop Task: Assessing Cognitive Performance under Exposure to Emotional Content. *Journal of Visualized Experiments*, *112*, 53720. https://doi.org/10.3791/53720

Berger, W., Coutinho, E., S., F., Figueira, I., Marques-Portella, C., Pires Luz, M., Neylan, T. C., Marmar, C. R. & Mendlowicz, M. V. (2011). Rescuers at risk: a systematic review and meta-regression analysis of the worldwide current prevalence and correlates of ptsd workers. Social Psychiatry and Epidemiology, 47, 1001-1011. https://doi.org/10.1007/s00127-011-0408-2

Blevins, C. A., Weathers, F. W., Davis, M. T., Witte, T. K., & Domino, J. L. (2015a). The Posttraumatic Stress Disorder Checklist for *DSM-5* (PCL-5): Development and Initial Psychometric Evaluation: Posttraumatic Stress Disorder Checklist for *DSM-5*. *Journal of Traumatic Stress*, *28*(6), 489–498. https://doi.org/10.1002/jts.22059

Bradley, M. M., & Lang, P. J. (1999). Affective norms for English words (ANEW): Instruction manual and affective ratings. *Technical report C-1, the center for research in psychophysiology, University of Florida. 30*(1) 25-36.

Bryant, R. A., & Harvey, A. G. (1997). Attentional Bias in Posttraumatic Stress Disorder. *Journal of Traumatic Stress*, *10*(4), 635–644. https://doi.org/10.1023/A:1024849920494

Cisler, J. M., Wolitzky-Taylor, K. B., Adams, T. G., Babson, K. A., Badour, C. L., & Willems, J. L. (2011). The emotional Stroop task and posttraumatic stress disorder: A meta-analysis. *Clinical Psychology Review*, *31*(5), 817–828. https://doi.org/10.1016/j.cpr.2011.03.007

Clausen, A. N., Youngren, W., Sisante, J.-F. V., Billinger, S. A., Taylor, C., & Aupperle, R. L. (2016). Combat PTSD and Implicit Behavioral Tendencies for Positive Affective Stimuli: A Brief Report. *Frontiers in Psychology*, *7*. https://doi.org/10.3389/fpsyg.2016.00758

Cohen, J. (1992). Statistical Power Analysis. *Current Directions in Psychological Science*, *1*(3), 98–101. https://doi.org/10.1111/1467-8721.ep10768783

Corrigan, J. D., & Bogner, J. (2007). Initial Reliability and Validity of the Ohio State University TBI Identification Method. *Journal of Head Trauma Rehabilitation*, *22*(6), 318–329. https://doi.org/10.1097/01.HTR.0000300227.67748.77

David, D., Lynn, S. J., & Montgomery, G. (Eds.). (2018). *Evidence-based psychotherapy: The state of the science and practice*. Wiley Blackwell.

Faul, F., Erdfelder, E., Buchner, A., & Lang, A.-G. (2009). Statistical power analyses using G*Power 3.1: Tests for correlation and regression analyses. *Behavior Research Methods*, *41*(4), 1149–1160. https://doi.org/10.3758/BRM.41.4.1149

Fleurkens, P., Rinck, M., & van Minnen, A. (2014). Implicit and explicit avoidance in sexual trauma victims suffering from posttraumatic stress disorder: A pilot study. *European Journal of Psychotraumatology*, *5*(1), 21359. https://doi.org/10.3402/ejpt.v5.21359

Foa, E. B., Feske, U., Murdock, T. B., Kozak, M. J., & McCarthy, P. R. (1991). Processing of threat-related information in rape victims. *Journal of Abnormal Psychology*, *100*(2), 156–162. https://doi.org/10.1037/0021-843X.100.2.156

Frayne, S. M., Chiu V. Y., Iqbal, S., Berg, E. A., Laungani, K. J., Cronkite, R. C., Pavao, J. & Kimerling, R. (2010). Medical care needs of returning veterans with ptsd: Their other burden. Journal of General Internal Medicine, 26, 33-39. https://doi.org/10.1007/s11606-010-1497-4

Gramlich, M. A., Neer, S. M., Beidel, D. C., Bohil, C. J., & Bowers, C. A. (2017). A Functional Near-Infrared Spectroscopy Study of Trauma-Related Auditory and Olfactory Cues: Posttraumatic Stress Disorder or Combat Experience?: fNIRS

Study of Trauma-Related Cues. *Journal of Traumatic Stress*, *30*(6), 656–665. https://doi.org/10.1002/jts.22239

Gramlich, M. A. (2019). Neurological Reactivity to Personalized Odors and Sounds in Combat-related Posttraumatic Stress Disorder (Doctoral Dissertation) https://stars.library.ucf.edu/etd/6761

Goodman, A. M., Katz, J. S., & Dretsch, M. N. (2016). Military Affective Picture System (MAPS): A new emotion-based stimuli set for assessing emotional processing in military populations. *Journal of Behavior Therapy and Experimental Psychiatry*, *50*, 152–161. https://doi.org/10.1016/j.jbtep.2015.07.006

Keane, T. M., Fairbank, J. A., Caddell, J. M., Zimering, R. T., Taylor, K. L., & Mora, C. A. (1989). Clinical evaluation of a measure to assess combat exposure. *Psychological Assessment: A Journal of Consulting and Clinical Psychology*, *1*(1), 53–55. https://doi.org/10.1037/1040-3590.1.1.53

Kessler, R. C., Petukhova, M., Sampson, N. A., Zaslavsky, A. M., & Wittchen, H.-U. (2012). Twelve-month and lifetime prevalence and lifetime morbid risk of anxiety and mood disorders in the United States: Anxiety and mood disorders in the United States. *International Journal of Methods in Psychiatric Research*, *21*(3), 169–184. https://doi.org/10.1002/mpr.1359

Khanna, M. M., Badura-Brack, A. S., McDermott, T. J., Shepherd, A., Heinrichs Graham, E., Pine, D. S., Bar-Haim, Y., & Wilson, T. W. (2016). Attention training normalises combat-related post-traumatic stress disorder effects on emotional Stroop performance using lexically matched word lists. *Cognition and Emotion*, *30*(8), 1521–1528. https://doi.org/10.1080/02699931.2015.1076769

Khanna, M. M., Badura-Brack, A. S., McDermott, T. J., Embury, C. M., Wiesman, A. I., Shepherd, A., Ryan, T. J., Heinrichs-Graham, E., & Wilson, T. W. (2017). Veterans with post-traumatic stress disorder exhibit altered emotional processing and attentional control during an emotional Stroop task. *Psychological Medicine*, *47*(11), 2017–2027. https://doi.org/10.1017/S0033291717000460

Kilpatrick, D. G., Resnick, H. S., Milanak, M. E., Miller, M. W. & Friedman, F. J. (2014). National estimates of exposures to traumatic events and ptsd prevalence using DSM-IV and DSM-V criteria. Journal of Traumatic Stress, 26(5), 537-547. 10.1002/jts.21848

Kimble, M. O., Frueh, B. C., & Marks, L. (2009). Does the modified Stroop effect exist in PTSD? Evidence from dissertation abstracts and the peer reviewed literature. *Journal of Anxiety Disorders*, *23*(5), 650–655. https://doi.org/10.1016/j.janxdis.2009.02.002

Kramer, L. B. (2020). *Self-Rated versus Clinician-Rated Assessment of Posttraumatic Stress Disorder: An Evaluation of Diagnostic Discrepancies between the PTSD Checklist for DSM-5 (PCL-5) and the Clinician-Administered PTSD Scale for DSM-5 (CAPS-5)*. [Doctoral dissertation, Auburn University].

Kroenke, K., Spitzer, R. L., & Williams, J. B. W. (2001). The PHQ-9: Validity of a brief depression severity measure. *Journal of General Internal Medicine*, *16*(9), 606 613. https://doi.org/10.1046/j.1525-1497.2001.016009606.x

Lang, P. J., Bradley, M. M., & Cuthbert, B. N. (2008). *International Affective Picture System (IAPS): Instruction manual and affective ratings*, *Technical Report A-8*. Gainesville: The Center for Research in Psychophysiology, University of Florida.

Morina, N., Wicherts, J. M., Lobbrecht, J., & Priebe, S. (2014). Remission from post -traumatic stress disorder in adults: A systematic review and meta-analysis of long-term outcome studies. Clinical Psychology Review, 34(3), 249-255. https://doi.org/10.1016/j.cpr.2014.03.002

National Center for PTSD. (n.d.). How common is ptsd in adults?. https://www.ptsd.va.gov/understand/common/common_adults.asp

National Center for PTSD. (n.d.). How is PTSD assessed?. https://www.ptsd.va.gov/understand/isitptsd/measured_how.asp

Olatunji, B. O., Armstrong, T., Bilsky, S. A., & Zhao, M. (2015). Threat modulation of visual search efficiency in PTSD: A comparison of distinct stimulus categories. *Psychiatry Research*, *229*(3), 975–982. https://doi.org/10.1016/j.psychres.2015.05.090

Olff, M., Polak, A. R., Witteveen, A. B., & Denys, D. (2014). Executive function in posttraumatic stress disorder (PTSD) and the influence of comorbid depression. *Neurobiology of Learning and Memory*, *112*, 114–121.

Pineles, S. L., Shipherd, J. C., Welch, L. P., & Yovel, I. (2007). The role of attentional biases in PTSD: Is it interference or facilitation? *Behaviour Research and Therapy*, *45*(8), 1903–1913. https://doi.org/10.1016/j.brat.2006.08.021

Pineles, S. L., Shipherd, J. C., Mostoufi, S. M., Abramovitz, S. M., & Yovel, I. (2009). Attentional biases in PTSD: More evidence for interference. *Behaviour Research and Therapy*, *47*(12), 1050–1057. https://doi.org/10.1016/j.brat.2009.08.001

Pineles, S. L., Suvak, M. K., Liverant, G. I., Gregor, K., Wisco, B. E., Pitman, R. K., & Orr, S. P. (2013). Psychophysiologic reactivity, subjective distress, and their associations with PTSD diagnosis. *Journal of Abnormal Psychology*, *122*(3), 635 644. https://doi.org/10.1037/a0033942

Polak, A. R., Witteveen, A. B., Reitsma, J. B., & Olff, M. (2012). The role of executive function in posttraumatic stress disorder: A systematic review. *Journal of Affective Disorders*, *141*(1), 11–21. https://doi.org/10.1016/j.jad.2012.01.001

Richardson, L. K., Frueh, B. C., & Acierno, R. (2010). Prevalence Estimates of Combat Related Post-Traumatic Stress Disorder: Critical Review. *Australian & New Zealand Journal of Psychiatry*, *44*(1), 4–19. https://doi.org/10.3109/00048670903393597

Sheehan, D., Lecrubier, Y., Harnett Sheehan, K., Janavs, J., Weiller, E., Keskiner, A., Schinka, J., Knapp, E., Sheehan, M., & Dunbar, G. (1997). The validity of the Mini International Neuropsychiatric Interview (MINI) according to the SCID-P and its reliability. *European Psychiatry*, *12*(5), 232–241. https://doi.org/10.1016/S0924-9338(97)83297-X

Stroop, J. R. (1935). Studies of interference in serial verbal reactions. *Journal of Experimental Psychology*, *18*(6), 643–662. https://doi.org/10.1037/h0054651

Taylor, S., Frueh, C. & Asmundson, G. J. G. (2007). Detection and management of malingering in people presenting for treatment of posttraumatic stress disorder: Methods, obstacles, and recommendations. Journal of Anxiety Disorders, 21(1), 22-41. https://doi.org/10.1016/j.janxdis.2006.03.016.

Wangelin, B. C. & Tuerk, P. (2015). Taking the pulse of prolonged exposure therapy: Physiological reactivity to trauma imagery as an objective measure of treatment response. Depression and Anxiety, 32, 927-934. https://doi.org/10.1002/da.22449

Weathers, F. W., Blake, D. D., Schnurr, P. P., Kaloupek, D. G., Marx, B. P., & Keane, T. M. (2013). Clinician-Administered PTSD Scale for DSM–5 (CAPS-5). Boston, MA: National 47 Center for PTSD.

Weathers, F. W., Bovin, M. J., Lee, D. J., Sloan, D. M., Schnurr, P. P., Kaloupek, D. G., Keane, T. M., & Marx, B. P. (2017). The Clinician-Administered PTSD Scale for DSM–5 (CAPS-5): Development and initial psychometric evaluation in military veterans. Psychological Assessment, 30, 383-395. doi: 10.1037/pas0000486

Wittekind, C. E., Behmer, F., Muhtz, C., Fritzsche, A., Moritz, S., & Jelinek, L. (2015). Investigation of automatic avoidance in displaced individuals with chronic Posttraumatic Stress Disorder (PTSD). *Psychiatry Research*, *228*(3), 887–893. https://doi.org/10.1016/j.psychres.2015.05.003