Psychophysiologic Assessment and Combat Post Traumatic Stress Disorder

Jeffrey M. Pyne, MD,1,2 and Richard Gevirtz, PhD, BCIA3

1Center for Mental Health and Outcomes Research, Central Arkansas Veterans Healthcare System, Little Rock, AR; 2Department of Psychiatry, College of Medicine, University of Arkansas for Medical Sciences, Little Rock, AR; 3Clinical Psychology PhD Program, CSPP @ Alliant International University, San Diego, CA

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Post traumatic stress disorder (PTSD) is a common mental health outcome associated with combat operations. Since October 2001, more than 1.6 million U.S. troops have deployed as part of Operation Enduring Freedom or Operation Iraqi Freedom. Current estimates for postdeployment post-traumatic stress disorder in Operation Enduring Freedom and Operation Iraqi Freedom veterans range from 5%–30%. This paper will briefly review a series of new and ongoing projects that utilize psychophysiologic assessment for patients with Operation Enduring Freedom or Operation Iraqi Freedom combat-related PTSD. Two treatment studies are supported by the Office of Naval Research, one assessment study is supported by the Veterans Health Administration, and a second assessment study is supported by the Department of Defense. Psychophysiologic reactivity is not new to combat-related PTSD, but there are new technologies that may enhance our ability to assess and understand this aspect of the condition. Papers describing the outcomes of these studies will be forthcoming.

Since October 2001, more than 1.6 million U.S. troops have deployed to the wars in Iraq and Afghanistan, with many exposed to prolonged and/or multiple deployments. These two conflicts are currently designated as Operation Enduring Freedom and Operation Iraqi Freedom (OEF/OIF). The recent RAND Corporation Report (Tanielian & Jaycox, 2008) summarized 22 prior studies of OEF/OIF veterans, giving a typical range of 5%–15% for veterans meeting postdeployment diagnostic criteria for post traumatic stress disorder (PTSD), with some studies reporting rates as high as 30%. The RAND report also estimated that approximately 300,000 returning service members currently suffer from PTSD and/or major depression.

Historically, the most common mental health sequelae of combat in treatment-seeking veterans is PTSD, although depression, substance abuse, and other anxiety disorders are also prevalent as comorbid or stand-alone conditions (Eisen et al., 2004; Price, Risk, Haden, Lewis, & Spitznagel, 2004). Associated with postdeployment mental health problems are decreased functioning (Amaya-Jackson et al., 1999; Kramer, Booth, Han, & Williams, 2003), familial disruption (Riggs, Byrne, Weathers, & Litz, 1998), higher health care utilization (Calhoun, Bosworth, Grambow, Dudley, & Beckham, 2002; Kramer et al., 2003; Schnurr, Friedman, Sengupta, Jankowski, & Holmes, 2000), and suicidal ideation (Kramer, Lindy, Green, Grace, & Leonard, 1994).

PTSD is characterized by three clusters of symptoms: (a) reexperiencing of the trauma; (b) avoidance of thoughts or acts that symbolize the trauma as well as emotional numbing; and (c) hyperarousal symptoms. The Diagnostic and Statistical Manual of Mental Disorders (American Psychiatric Association, 2000) diagnostic criteria for PTSD require at least one of five symptoms of reexperiencing; at least three of seven symptoms of avoidance and numbing; and at least two of five symptoms of hyperarousal. The severity of symptoms within each category may vary over time. Most postcombat veterans will demonstrate a spontaneous decay or resolution of symptoms over time (Kulka et al., 1990). In the National Vietnam Veterans’ Readjustment Study, the rate of current PTSD 10 to 20 years after deployment to Vietnam was 15.2% among men and 8.5% among women (Kulka et al., 1990). In the same study, 31% of men and 27% of women met criteria for lifetime PTSD (Schlenger et al., 1992). More recent estimates of current and lifetime PTSD from these data were 9.1% and 18.7%, respectively (Dohrenwend et al., 2006).

This paper will briefly review a series of projects that include psychophysologic assessment in patients with combat-related PTSD: two treatment studies and two assessment studies.

Psychophysiologic Reactivity in Treatment Studies

The treatment studies are being conducted primarily at Navy Medical Center San Diego and are funded by the Office of Naval Research. Both studies used virtual reality (VR) technology to facilitate exposure therapy in active duty military personnel. VR technology integrates computer
graphics and a headgear device that tracks head movement and changes the visual display appropriately. The technology allows for a vivid lifelike reexposure to traumatic reminders in a safe and controlled manner (Spira et al., 2006). VR is increasingly being used to facilitate exposure therapy for PTSD (Difede et al., 2007; Rothbaum, Hodges, Ready, Graap, & Alarcon, 2001; Wood et al., 2008). Both studies recruited participants who had failed at least one previous PTSD treatment trial (medications or psychotherapy). In one study, physiologic reactivity during the treatment sessions was used to inform the therapist about the level of arousal, and in the other study physiologic reactivity during the treatment sessions was not used.

Physiologic reactivity to trauma reminders was measured as part of the baseline and follow-up assessments for both studies. Physiologic reactivity included heart rate, heart rate variability, and skin conductance measurements. The stimuli used to measure physiologic reactivity, however, differed in the two studies. The stimulus in one study was imaginal and used to measure physiologic reactivity, however, differed in the two studies. The stimulus in one study was imaginal recall of a trauma event related to their PTSD symptoms and the other study used a standardized VR combat scenario.

**Psychophysiologic Reactivity in Assessment Studies**

Increased trauma-specific physiologic reactivity has been associated with poor outcomes since at least World War I (WWI). For example, WWI soldiers who demonstrated increased physiologic reactivity to combat reminders were unable to return to the combat zone (Meakins & Wilson, 1918). World War II soldiers with increased psychophysiologic reactivity had worse mental health outcomes (Kardiner, 1941). More recent studies found that physiologic reactivity (increased heart rate, cardiac acceleration, skin conductance, and more pronounced eye-blink response) to audiovisual cues of combat and individually tailored imagery scripts of stressful combat experiences discriminated between combat veterans with PTSD, veterans without PTSD, and veterans with other psychiatric disorders (Blanchard, Kolb, & Prins, 1991; Metzger et al., 1999; Orr, Metzger, & Pitman, 2002; Pitman, Orr, Forgue, de Jong, & Claiborn, 1987; Shalev et al., 2000; Wolfe et al., 2000). Even 20 years after combat exposure, physiologic reactivity measures (heart rate, skin conductance, and eye-blink startle) correctly classified two thirds of veterans with and without PTSD when they viewed static combat-related visual stimuli and listened to combat-related audio and personalized trauma scripts (Keane et al., 1998).

The studies focusing primarily on psychophysiologic assessment are being conducted at the Central Arkansas Veterans Healthcare System (CAVHS). One study is recruiting participants postdeployment and the other will be recruiting participants predeployment.

**Postdeployment Study**

The aims of the postdeployment study are: (a) to compare objective psychophysiologic predictors of OIF/OEF combat-related PTSD symptom severity to self-report predictors and (b) to examine the acceptability of psychophysiologic measures as screening and outcome monitoring tools for OIF/OEF combat-related PTSD. The primary goal is to collect psychophysiologic reactivity, self-report, and PTSD symptom severity data from 150 OIF/OEF postdeployment veterans (60 PTSD treatment-seeking veterans from the CAVHS mental health clinic and 90 OIF/OEF non–treatment-seeking veterans from the Arkansas National Guard) and examine the relationship between psychophysiologic measures and PTSD symptom severity. This study is funded by the Veterans Health Administration.

Pathological fear structures inherent in anxiety disorders, such as PTSD, involve excessive response to fear-associated stimuli (e.g., psychophysiologic reactivity) (Foa & Kozak, 1986). Avoidance of trauma reminders is a symptom of PTSD; therefore, exposure to context-specific stimuli provides more direct access to the fear structure and so may allow for more direct psychophysiologic assessment of PTSD symptom severity. In this study we are examining physiologic reactivity (heart rate, heart rate variability, skin conductance, eye-blink startle) in response to the following stimuli: auditory (white-noise startle and VR) and visual (VR, Stroop, eye-gaze tracking). Each of these stimulus elements are context-specific (combat) except for the standard white-noise startle stimulus.

Increased acoustic startle has long been recognized as an important symptom of PTSD. Increased eye-blink response to acoustic startle is reported in most but not all studies comparing PTSD and non–PTSD groups (Orr et al., 2002) and appears to be a more context-specific response (Grillon, Morgan, Davis, & Southwick, 1998). Slowed skin conductance habituation appears to be a consistent correlate of PTSD (Metzger et al., 1999; Orr, Solomon, Peri, Pitman, & Shalev, 1997). Shalev and colleagues have reported greater heart rate response to acoustic startle at 1 to 4 months posttrauma in individuals with PTSD versus those without PTSD (Shalev et al., 2000; Shalev et al., 1998). The landmark study of Orr and colleagues supports the secondary acquisition of increased startle through increased heart rate response to acoustic startle in Vietnam combat veterans with PTSD, but not in their non–combat-exposed co-twins or Vietnam combat veterans without PTSD (Orr et al., 2003). Evidence also suggests that startle response in patients with PTSD may be related directly to...
PTSD symptom severity (Veazey, Blanchard, Hickling, & Buckley, 2004). Based on these results, we are examining physiologic reactivity to acoustic startle responses using a standard white-noise startle protocol and using contextually relevant auditory stimuli within VR environments.

The VR environ includes a standardized combat and standardized civilian environment. The VR environments are brief (3 minutes each), inserted between three rest periods of approximately 5 minutes each. The VR environments are standardized so that each subject moves through the environment as if on a moving path. At the same time the VR technology allows for participant immersion, because participants can look anywhere in the environment they want to as they move through the environment (Wiederhold & Wiederhold, 2000).

In the modified Stroop task, participants name the color in which disorder-relevant and non–disorder-nonrelevant words are written as quickly as they can, while attempting to ignore the actual word content. Slower color naming (increased response latency) is an indicator of the degree that the content of the word interferes with color naming. The activation of the competing response to processing word meaning is defined as attentional bias. Studies examining groups with combat-related PTSD (Litz et al., 1996) and non-combat PTSD (Bryant & Harvey, 1995) have demonstrated increased response latencies for PTSD threat words compared with control groups. The Stroop effect, like physiologic reactivity, represents an automatic process that a subject cannot strategically control (Constans, McCloskey, Vasterling, Brailey, & Mathews, 2004).

Measuring eye movements to competing threatening and nonthreatening stimuli may provide a more directly observable and “ecologically valid” measure of attentional bias (Mogg, Millar, & Bradley, 2000). Unlike modified Stroop paradigms, which evaluate postrecognition information processing, eye movements can capture initial orientation and are neither subject to postrecognition processing nor dependent on motor response times. Gaze direction (where a subject is actually looking on a monitor screen) is another measure of attentional bias (Eizenman et al., 2003). Eye-gaze tracking methods were used to assess total fixation time and average glance duration to dysphoric and nondysphoric images in depressed and healthy control subjects (Eizenman et al., 2003). The average glance duration on images with dysphoric themes during free view was significantly longer for participants with depressive disorders compared with controls. These findings suggest that eye-tracking methods are capable of measuring emotional information processing and initial attentional bias to stimuli using mood-congruent and mood-incongruent images.

Examples of physiologic reactivity that are being used in this study include: heart rate variability (HRV), skin conductance, and eye-blink startle. HRV is being measured during VR exposure, skin conductance is being measured during VR exposure and white-noise startle, and eye-blink startle is being measured during white-noise startle. Additional psychophysiologic measures include Stroop reaction time and eye-gaze tracking to visual stimuli. Stroop reaction time is measured by asking participants to name (a) the color of the letters used to display neutral, general threat, and combat words and (b) the background color used to display angry and neutral facial images. Eye-gaze tracking is measured while the participant is viewing paired combat/neutral and angry/neutral images.

There has been increased interest in HRV as a physiologic marker for PTSD (Cohen et al., 2000). HRV has been measured in a variety of mental illnesses, including generalized anxiety disorder, schizophrenia, panic disorder, and PTSD (Cohen et al., 2000). Diminished HRV in PTSD patients is typically understood as evidence of autonomic dysregulation; however, the interpretation of HRV changes is controversial (Porges, 2007). We are measuring HRV at baseline (prior to any testing), during VR with civilian and Iraqi environments, and during the VR rest periods.

As mentioned above, skin conductance and electromyography (EMG) are commonly measured in acoustic startle procedures. We are measuring skin conductance and EMG response score (peak minus baseline) (Metzger et al., 1999; Orr, Lasko, Shalev, & Pitman, 1995; Orr et al., 1997; Shalev et al., 2000) and habituation scores (two consecutive responses below a minimal threshold and the slope of the skin conductance peak response regression line) (Metzger et al., 1999; Orr et al., 1995; Shalev et al., 2000).

Objective psychophysologic and self-report predictor models will be constructed using the Clinician Administered PTSD Scale (CAPS) as the dependent variable (Newman, Kaloupek, & Keane, 1996). The prediction models will be built using a forward purposeful selection method advocated by Hosmer and Lemeshow (2000). The sensitivity and specificity of the resulting prediction models will be described and the models will be compared using the McNemar test to compare participants categorized according to their estimator probability and standardized residuals. We will also calculate the area under the receiver operating characteristics (ROC) curve for each model, use bootstrap methods to estimate the variances for each area under the curve (AUC) (Efron & Tibshirani, 1993), and test for AUC differences between the models using a two-tailed $t$ test. In addition, the acceptability of psychophysologic measures as screening and outcomes monitoring tools will be assessed using qualitative methods.
Predeployment Study

The recent Department of Defense mental health task force also highlighted the mental health needs of National Guard personnel. The Task Force reported that 49% of National Guard personnel, 38% of active duty soldiers, and 31% of active duty Marines report mental health problems on the Post-Deployment Health Reassessment (PDHRA), which is administered 90 to 120 days after returning from deployment (Department of Defense Task Force on Mental Health, 2007). Based on PDHRA data, the National Guard/Reserve rate of meeting criteria for mental health referral was nearly twice that of active duty soldiers (55.1% versus 27.0%) (Milliken, Aechterlonie, & Hoge, 2007).

To our knowledge, no predeployment studies have used physiologic reactivity or cognitive bias measures to predict postdeployment PTSD. However, a prospective firefighter study measured physiologic reactivity to acoustic startle during training (pretrauma exposure) and within 4 weeks after trauma exposure and found that pretrauma eye-blink startle and skin conductance responses to acoustic startle predicted PTSD symptom severity (Guthrie & Bryant, 2005). Acoustic startle response also discriminated between children with and without family histories of depression and anxiety, suggesting biologic vulnerability to both disorders (Grillon & Morgan, 1999). The firefighter study also found that pretrauma cognitive bias predicted PTSD symptoms in firefighters, even after removing variance associated with a number of other risk factors (Bryant & Guthrie, 2005). In a sample of college students, biases in a certain form of cognitive processing, referred to as attributional style, predicted onset of depressive disorders (Alloy et al., 2006).

The aims of the predeployment study are: (a) to develop and test predeployment objective predictors (physiologic reactivity and cognitive bias) of postdeployment PTSD outcomes and (b) to test resilience-building interventions targeting physiologic and cognitive responses to combat stress. This study recently was approved for funding and will enroll 500 Army Reserve National Guard personnel within the 6 months before they deploy for OIF/OEF missions. We will collect predeployment physiologic reactivity and cognitive bias data, deliver predeployment prevention interventions, and collect postdeployment PTSD outcome data. After collecting predeployment data, participants will be randomized to one of three groups: HRV biofeedback training, cognitive bias modification training, or no additional training. This study is funded by Department of Defense.

Predeployment physiologic reactivity assessment will include heart rate, HRV, skin conductance, and eye-blink startle in response to white-noise startle and VR combat environments. Predeployment cognitive bias assessment will include participant responses to ambiguous combat and noncombat scenarios. HRV biofeedback will follow the usual training described by Lehrer, Vaschillo, and Vaschillo (2000) and Gevirtz (2007). Once participants have mastered the basic resonant frequency training (RFT), they will train on videogames being developed that require RFT but then also demand motor skills and wide focus. Cognitive bias training will be accomplished using a computer interface followed by practice with a handheld device to reinforce training. Postdeployment assessments will include a variety of mental health outcome measures. It is hypothesized that strengthening homeostatic reflexes in the autonomic nervous system will help prevent or lessen the encoding of trauma memories, emotions, and cognitions.

Conclusion

Psychophysiologic reactivity is not new to combat-related PTSD, but there are new technologies that may enhance our ability to assess and understand this aspect of PTSD. Papers describing the outcomes of these studies will be forthcoming.

References


Wiederhold, B. K., & Wiederhold, M. D. (2000). Lessons learned from 600 virtual reality sessions. *Cyberpsychology and Behavior, 3*, 393–400.


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