TRAUMATIC BRAIN INJURY AND POSTTRAUMATIC STRESS DISORDER: A QUANTITATIVE INVESTIGATION OF VISION AND ATTENTION

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DEDICATION

This thesis is dedicated to all of the men and women who have served and fought for our country.

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ABBREVIATIONS

ANT = Attention Network Task
LANT = Lateralized Attention Network Task
LH = Left Hemisphere
LVF = Left Visual Field
mTBI = Mild Traumatic Brain Injury
OIF/OEF = Operation Iraqi Freedom/Operation Enduring Freedom
PTSD = Posttraumatic Stress Disorder
RH = Right Hemisphere
RVF = Right Visual Field

ABSTRACT

TRAUMATIC BRAIN INJURY AND POSTTRAUMATIC STRESS DISORDER: A QUANTITATIVE INVESTIGATION OF VISION AND ATTENTION

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Mild traumatic brain injury (mTBI) and posttraumatic stress disorder (PTSD) are prevalent dual impairments in Veterans returning from the wars in Iraq and Afghanistan. There is little existing research that investigates the problems and complaints that these disorders share. The purpose of this study was to determine what types and levels of visual and attentional deficits that may be evident among polytrauma populations and to establish quantitative profiles of visual attention performance in those with isolated PTSD diagnosis, versus those with comorbidity of PTSD and TBI. We used a lateralized version of the Attention Network Task to measure the speed and accuracy with which subjects can shift attention to locations in the visual field, therefore, measuring hemispheric asymmetries in attentional performance. Overall, we found that TBI patients were slower and less accurate in their attentional performance when compared to PTSD and Control groups. We found that these deficits were worse when TBI patients were presented with spatial cue and no-cue conditions when the stimuli were presented to the left visual field (LVF) and processed by the right hemisphere (RH). We also found substantially higher intra-subject variability of TBI patient responses when compared to PTSD and Control Groups. Our results also indicate that TBI patients who self-report relatively high levels of attention problems in everyday activities performed significantly

worse on behavioral measures of attention when orienting to the LVF, indicating a RH deficit.

INTRODUCTION

More than 1.5 million U.S. military personnel have deployed to Iraq or Afghanistan since the start of military operations in 2001 (Hoge et al., 2008). As of January 2008, over 29,000 of these individuals were physically wounded, but many more return from deployments with mental health symptoms (Batten & Pollack, 2008). Mild traumatic brain injury (mTBI) has been called "the signature injury" from the war in Iraq and Afghanistan (NCO Update, 2008). However, many troops are also returning from deployment suffering from Posttraumatic Stress Disorder (PTSD) from their experience that initiated the mTBI. Preliminary research indicates that PTSD manifests visual and attentional symptoms similar to individuals with mTBI (Goodrich, 2008). These functional impairments include blurry vision, diplopia, and problems with concentration and attention.

Attention is a complex process where disturbance is considered a core deficit in a number of disorders (Riccio, Reynolds, Lowe, & Moore, 2002). Brain injury cases cause a variety of neuropsychological impairments and one of the most common cognitive disturbances are difficulties with attention (Bate, Mathias, & Crawford, 2001; Cremona-Meteyard, Clark, & Geffen, 1992; Pavolvskaya, Groswasser, Keren, Mordvinov, & Hochstein, 2006; Whyte, Brieb-Neff, Gantz, & Polansky, 2006). Consistent among empirical studies, mTBI patients perform slower on response tasks and are unable to focus attention to more than one thing at a time. Such deficits can cause functional impairments in everyday living for mTBI sufferers. Studies investigating the

neuropathology of head trauma suggest that the frontotemporal susceptibility to injury is the core reason for these problems in attention (Bigler, 2007).

Another common mental disorder that reports attentional dysfunction is Posttraumatic Stress Disorder (PTSD). Past studies that have investigated the neuropsychiatric manifestations of attention suggest impairment in focused and sustained attention (Jenkins, Langlais, Delis, & Cohen, 2000; Vasterling et al., 2002) and the executive functioning of attention (Leskin & White, 2007). Similar to the attentional deficits found in mTBI patients, these problems in attention pose many difficulties in PTSD patients' overall quality of life. Deficits in executive functioning reveal PTSD patients' inability to ignore irrelevant information or distractions. Neuroanatomical investigations of these problems suggest dysfunction in the prefrontal cortex and anterior cingulate (Fan, McCandliss, Fossella, Flombaum, & Posner, 2005; Leskin & White, 2007).

This study is an attempt to investigate the visual and attentional abilities of troops returning from Operations Iraqi Freedom (OIF) or Enduring Freedom (OEF). The results of this study will help to contribute to ongoing research on OEF/OIF veterans and help to establish quantitative profiles of visual and attentional performance in those with isolated mTBI and PTSD diagnosis, versus those with comorbidity.

MILD TRAUMATIC BRAIN INJURY (MTBI)

Definition – DSM-IV-TR

According to the DSM-IV-TR, the defining criterion for diagnosing postconscussional disorder, also known as a mTBI, is a history of head trauma that has caused a concussion. Evidence from neuropsychological testing or quantified cognitive assessment should also indicate difficulty in attention, i.e., concentrating, shifting focus of attention, performing simultaneous cognitive tasks, or memory, i.e., learning or recalling information. Criteria also include the three or more of the following symptoms within the last three months: becoming fatigued easily, disordered sleep, headache, vertigo or dizziness, irritability or aggression on little or no provocation, anxiety, depression, or affective lability, changes in personality, apathy or lack of spontaneity.

TBI diagnosis and screening at a VA hospital

The key factors in diagnosing a case of mTBI include an injury event, such as a blow to the head, which causes an alteration of consciousness. Examples of this alteration include losing consciousness, "seeing stars", or simply being temporarily disoriented. (NCO update, 2008). The Defense and Veterans Brain Injury Center (DVBIC) has devised a three question DVBIC TBI screening tool (see appendix A) to help identify veterans who may be suffering from a TBI. A national clinical reminder, VA-TBI screening was implemented for every veteran returning from OIF/OEF as of April 13th, 2007 (VHA Directive 2007-013, 2007, see appendix B). A patient screens positive if they endorse an injury (Question 1), as well as an alteration of consciousness (Question 2 A-E). The service member will then be evaluated via clinical interview

because he/she is more highly suspect for having sustained a mTBI or concussion. The mTBI screen alone does not provide diagnosis of mTBI. After a clinical interview, if a veteran screens positive, they are offered a comprehensive evaluation by a Component II or a Component III polytrauma team. Results from preliminary mTBI screenings indicate significant differences in reaction times, concentration, and short-term memory in soldiers reporting mTBI incidents. Post-deployment, a soldier may be irritable, sleepless, clumsy, and suffering from chronic headaches and memory loss (NCO Update, 2008). As of April 2, 2007, the Department of Veterans Affairs started TBI screening all on Operation Iraqi Freedom (OIF) or Operation Enduring Freedom (OEF) veterans who visit a VA facility (VHA Directive 2007-013, 2007).

Prevalence of mTBI in OIF/OEF Veterans

Traumatic brain injury (TBI) has been called the "signature injury" of the Iraq War (NCO Update, 2008). Head and neck injuries have been reported in one quarter of the troops who have been evacuated from Iraq and Afghanistan (Okie, 2005). "We are going to have a large population of individuals with significant brain impairment who are going to have difficulty navigating through every day life," says William Perry, PhD, president of the National Academy of Neuropsychology (NCO Update, 2008). In March 2008 at Landstuhl Regional Medical Center in Germany which treats all service members wounded in Iraq and Afghanistan who are evacuated for medical treatment, 240 inpatient service members were interviewed and 80 screened positive for TBI symptoms. The exact proportion of troops who have mTBI is not known, although it has been reported to be as high as 18% (Carson study, 2007). Improvised explosive devices (IEDs), landmines, high pressure waves from blasts, and explosive fragments account for the

majority of combat related injuries in Afghanistan and Iraq. Kevlar helmets and advances in body armor have saved the lives of many soldiers; however, this equipment does not totally protect against blast injuries. Even if soldiers are not directly hit, the shockwaves of these explosions can violently shake their brains or send shrapnel into their helmets. As a result, a higher percentage of soldiers are surviving injuries that would have been fatal in previous wars (Okie, 2005).

POSTTRAUMATIC STRESS DISORDER (PTSD)

Definition – DSM-IV-TR

Posttraumatic Stress Disorder is defined by the DSM-IV-TR (2000) as being exposed to traumatic event in which the person experienced, witnessed or was confronted with an event that involved actual or threatened death or serious injury, or a threat to the physical integrity of self or others that resulted in a response that involved fear, helplessness, or horror. The traumatic event must also be persistently re-experienced in one of the following ways: 1) recurrent and intrusive distressing recollections of the event, including images, thoughts or perceptions, 2) recurrent dreams of the event, 3) acting or feeling as if the traumatic event were recurring, 4) intense psychological and/or physiological distress at exposure to internal or external cues that symbolize or resemble an aspect of the traumatic event. Diagnosis is also identified by persistent avoidance of stimuli associated with the trauma and persistent symptoms of increased arousal. Durations of the symptoms must be present for at least 1 month and cause clinically significant distress or impairments in social, occupational, or other important areas of functioning.

History of PTSD Research

Despite many accounts of PTSD over that last few centuries (Myers, 1915), it was only formally recognized as a psychiatric disorder in the third edition of the *Diagnostic and Statistical Manual of Mental Disorders* (American Psychiatric Association, 1980). Since then, considerable research has been completed over the last several decades to investigate the etiology, phenomenology, clinical and neurobiological characteristics, and

treatment of PTSD. In order to satisfy the current *DSM-IV-TR* criteria (American Psychiatric Association, 2000), an individual has to be exposed to a traumatic event that involves actual or threatened death or serious injury, or a threat to the physical integrity of self or others. Jacob Mendez Da Costa, a Philadelphia physician, describes a condition resembling PTSD among veterans on the American Civil War (Nemeroff et al., 2006). The relatively high occurrence of PTSD among Vietnam Veterans also fueled the rise in research pertaining to this disorder.

Several topics have been reportedly investigated: sex differences, risk and resilience after disasters and terrorism, relation to early life trauma, and neurobiology. In the National Comorbidity Survey, Kessler, Sonnega, Bromet, Hughes, & Neslon (1995) found that an overall prevalence of PTSD to be 7.8% of the population, but women were over twice as likely as men to have suffered from the condition. Studies that look at risk and resilience factors after disasters and terrorism reveal that PTSD symptoms gradually diminish over time, perhaps due to interpersonal relationships, spirituality, and/or community cohesiveness. In a longitudinal study by Silver, Holman, & McIntosh (2002), they found that the prevalence of PTSD symptoms related to September 11th among the US population declined from 17% at 2 months to 5.8% at 6 months. Research also indicates that early trauma is indeed a principal risk factor for later depression and anxiety disorders (Nemeroff et al, 2006). As for the neurological mechanisms chiefly involved in PTSD, the symptoms of this diagnosis can be traced to an impairment of the right brain (Schore, 2002). The neural circuitry implicated in PTSD involves complex interactions between the thalamus (a gateway for sensory inputs), the hippocampus (which is involved in memory), the amygdala (involved in conditioned fear responses),

the posterior, parietal, and motor cortex (which is involved in visuospatial processing and assessment of threat), and the medial prefrontal cortex (Nemeroff et al., 2006).

PTSD screening and diagnosis at a VA hospital

Similar to the TBI screen at the VA, a veteran is asked a series of questions at their first intake appointment. The following health care providers can perform initial examinations for PTSD: board certified psychiatrist, licensed doctorate level psychologist, doctorate-level mental health provider, psychiatry resident, or a clinical or counseling psychologist completing a one-year internship or residency. The initial PTSD screen for VISN 6 includes the following questions:

> Have you ever had any experience that was so frightening, horrible, or upsetting that, in the past month, you:
>
> A. _____Have had any nightmares about it or thought about it when you did not want to? (Yes/No)
> B. _____Tried hard not to think about it; went out of your way to avoid situations that remind you of it? (Yes/No)
> C. _____Were constantly on guard, watchful, or easily startled? (Yes/No)
> D. _____Felt numb or detached from others, activities, or your surroundings? (Yes/No)

If a veteran screens positive for PTSD, they are then referred to a mental health provider.

It is important to note that an accumulating body of empirical data suggests that current Department of Veteran Affairs psychiatric disability and rehabilitation policies for combat-related PTSD are problematic (Frueh, Anouk, Grubaugh, Elhai, & Buckley, 2007). However, when the Department of Veteran Affairs makes a PTSD diagnosis, they require medical evidence establishing a diagnosis of the condition that conforms to the diagnostic criteria of DSM-IV-TR (2000), credible supporting evidence that the claimed in-service stressor actually occurred, and a link, established by medical evidence, between current symptom and the claimed in-service stressor. A diagnosis of PTSD

cannot be adequately documented or ruled out without obtaining a detailed history and evaluation. The following information is taken into account during a PTSD evaluation: 1) Identifying information, 2) Sources of additional information (i.e. records, social-industrial survey, psychometric tests and questionnaires), 3) Review of medical records, 4) Examination (objective findings) and History (subjective complaints), 5) Mental status examination, 6) Assessment of PTSD, 7) Psychometric Testing Results, and 8) Diagnosis (Initial Evaluation of PTSD, n.d.). The psychometric testing results determine whether the measures are consistent or inconsistent with a diagnosis of PTSD, based on normative data and established "cutting scores." Cutting scores that are consistent with a diagnosis of PTSD are as follows: PCL(PTSD checklist) -scores not less than 50; Mississippi Scale – not less than 107; MMPI-PTSD subscale score > 28; and MMPI code type: 2-8, 2-7-8. A diagnosis of PTSD takes into account criteria of the DSM-IV-TR and the effects of the signs and symptoms on occupational and social functioning (Initial Evaluation of PTSD, n.d.).

Early epidemiologic studies illustrate how easy it is to miss a diagnosis of PTSD without the right investigative tools. One of these reasons is comorbidity. Comorbitity is a problematic challenge in the study of cognitive deficits in PTSD because it can potentially obscure the contribution of cognitive deficits of PTSD. It is suggested that 84% of individuals with PTSD meet criteria for at least one other psychiatric disorder (Kessler et al., 1995). PTSD is associated with increased rates of Major Depressive Disorder, Generalized Anxiety Disorder, Substance Related Disorders, Panic Disorder, Agoraphobia, Obsessive-Compulsive Disorder, and Phobias (American Psychiatric Association-TR, 2000). Many of the neuropsychological complaints of PTSD are likely

to coexist with and be influenced by features of these other diagnoses. Therefore, cognitive impairments should be interpreted cautiously, as the findings leave open the question as to whether the deficits are attributable to PTSD per se or other uncontrolled factors (Danckwerts & Leathem, 2003).

PTSD Prevalence in Veterans

The prevalence of PTSD among Vietnam theater veterans, as reported from the United States National Comorbidity Survey (NCS) is 30.6% for men and 26.9% for women; an additional 22.5% of these men and 21.2% of these women have had partial PTSD at some point in their lives (Kessler et al., 1995). Thus, more than half of all male Vietnam veterans and almost half of female Vietnam veterans have experienced "clinically serious stress reaction symptoms" (Kessler et al., 1995). The precise prevalence of PTSD in troops returning from Iraq and Afghanistan is not known. However, of the first 299,585 OEF/OIF veterans accessing VA health care, mental disorders ranked second for most common health problem reported. Within the mental disorders category, PTSD was the most common complaint over substance abuse and depression (Batten & Pollack, 2008). Also, the Department of Defense combined with Post-Deployment Health Assessment screening have indicated that 20.3% to 42.4% of soldiers returning from OIF/OEF require mental health treatment. These rates are consistent among recent veterans seeking care at Veteran Affairs facilities (Milliken, Auchterlonie, & Hodge, 2007).

Background of the Psychological Theory of Attention

Why is the study of attention important and what does it tell us? In our daily lives, we are confronted with far more information and stimuli than we can process simultaneously. Our attentional systems play an important filtering role, allowing us to focus on task demands and relevant sensory information while ignoring irrelevant and distracting stimuli (Posner, 1989). By filtering irrelevant information, it allows for more enhanced functioning in the environment.

A popular account of visual attention proposes that there are three independent networks of attention (*Alerting*, *Orienting*, and *Executive*), each performing a separate function (Posner & Petersen, 1990). Posner and Petersen (1990) explained that these subsystems of attention are divided because they have different but interrelated functions. The *Alerting* network generates a state of alertness and vigilance that enables efficient processing of upcoming events, the *Orienting* network shifts the focus of attention from one location to another and selectively allocates attention to specific stimuli, and the *Executive* network facilitates selective attention to specific stimuli and resolve conflict among competing responses to those stimuli. Posner and Petersen (1990) also investigated the neuroanatomical correlates of these networks. In the *Alerting* network, they have provided evidence that sustained attention tasks exhibit prefrontal and parietal activation, most commonly in the right hemisphere (RH). In examining tasks involving conflicting stimuli, the *Executive* network, the anterior cingulate cortex and left prefrontal cortex were found to be activated (Fan et al., 2005). Orienting of attention to sensory

stimuli in the environment activates the parietal and frontal lobes (Fan et al., 2005), and some research indicates greater activation in the right hemisphere (Corbetta, Patel, & Schulman, 2008).

Original Attention Network Task

Fan et al. (2002) developed a simple behavioral test of the efficiency of these three networks called the Attentional Network Task (ANT). This 30-minute computerized test presents target stimuli either above or below a central fixation point that may or may not be accompanied by flanker stimuli that can distract attention. On some trials, spatial cues to the target's location are presented just prior to the target's occurrence. The efficiency of each network is calculated by measuring the response time and accuracy in these various conditions. This task can be used by children or the elderly, can measure attentional problems in cases of brain injury, and can also evaluate other disorders with underlying attention deficits (i.e., stroke, schizophrenia, and attention deficit hyperactivity disorder).

Lateralized Attention Network Task

While attention is believed to be composed of bilaterally distributed networks (Greene et al., 2008), there is also evidence the hemispheric asymmetries exist in neural activation levels as well as efficiency of attentional function. To better understand the nature of these asymmetries, several researchers have recently developed a lateralized version of the ANT (Greene et al., 2008; Poynter, Ingram, & Minor, 2010). The lateralized attention network task (LANT) is beneficial in measuring the Executive, Orienting, and Alerting networks in each hemisphere. Stimuli are flashed to the right and left of fixation, instead of above and below it as in the original ANT. Green et al. (2008)

utilized this task to test the efficiency of attention and found that the three networks were indeed represented in each hemisphere, but did not observe any behavioral asymmetries of attentional function. Poynter et al. (2010) studied visual field asymmetries in a cohort with varying levels of self-reported attentional problems. Their results suggest a left visual field (right hemisphere) deficiency in the *Orienting* metric in subjects with high levels of self-reported attention problems in everyday tasks.

Attentional Networks and Neuroanatomical Correlates of mTBI

Over 50 years ago, Courville (1950) proposed that the frontal and temporal lobes are the most susceptible to injury. This frontotemporal susceptibility to injury is neuropsychologically associated with the core cognitive and neurobehavioral symptoms of TBI, impairments in attention, concentration, memory, executive function, and emotional regulation (Bigler, 2007). Among the many deficits found in brain injury is the inability to maintain performance in the face of competing information. This form of selective attention is most closely related to the Executive control or Conflict resolution network of attention (Posner, 1990). But there is also experiemental evidence that the Orienting network is also impacted by TBI. Pavolvskaya and colleagues (2006) examined the hemispheric visual attentional asymmetries in patients with TBI. They presented visual cues to the left and right visual field as ipsi- and cross hemi-field targets. Valid cues were presented in the same visual field (ipsilateral trials) and invalid cues were presented to the opposite field (cross-trials) thus requiring a left or right shift of attention. They found a significant asymmetry in performance of attention-shifting tasks in TBI patients (the Orienting attentional network as described above). TBI patients were less efficient at shifting their visual attention to the Left Visual Field (LVF), perhaps

indicating a Right Hemisphere deficiency. The right hemisphere is proposed to control attention to both the RVF and LVF, while the left hemisphere controls attention to only the RVF (Riccio et al., 2002). However, because traumatic brain injury is diffuse and not allocated to one hemisphere, Pavolvskaya et al.'s (2006) results exhibit that damage to both hemispheres resulted in a neglected LVF. More interestingly, the same deficit to the LVF is found in subjects with attention-deficit hyperactivity disorder (ADHD) (Geeraerts, Laafosse, Vaes, Vandenbussche, & Verfaillie, 2008) suggesting that perhaps the same neuroanatomical origins affected by mild traumatic brain injury may also be found in ADHD.

In a similar study conducted by Van Donkelaar and colleagues (2005), they used the original ANT to also measure the three attentional networks in subjects that had sustained a concussion from intra-mural sports or recreational activities. They found that only the orienting and executive components of attention were affected by concussion; however, the alerting component remained unaffected. More specifically, their results suggest only a mild influence in the *Executive Network* and larger influence in the *Orienting Network.* They suggest that the neuroanatomical correlates involved in the brain's ability to maintain alertness is not influenced by a concussion. They attribute the mild influence of the *Executive Network* to the distractibility of patients with a concussion. They found that when presented with distracting stimuli during incongruent trials, participants with concussion had longer reaction times. This inability to ignore distracting stimuli engages the anterior cingulate cortex. The *Orienting Network* displayed the most significant influence with the longest reaction time when participants were not presented with a pre-cue. The neuroanatomical regions involved in moving

attention from a central fixation point to search for stimuli include the superior parietal lobe and the intra-parietal sulcus of the posterior parietal cortex. The anatomical areas involved when stimuli were not preceded by a pre-cue were the dorsolateral and ventromedial pre-frontal areas (Van Donkelaar et al., 2005). Overall, they conclude that these areas of the brain are most susceptible to concussion while the neuroanatomical regions that involve the alerting component are not affected.

However, there is a discrepancy in the results of TBI studies using the "orienting of attention" paradigm presented by Posner (1980). Using Posner's Covert Orienting of Attention Task (COAT), Bate et al. (2001) found no difference between control subjects and TBI patients in orienting of attention. However, they did find that the reaction times of TBI subjects were significantly slower than controls. They attribute this slower response time to reduced speed of information processing. On the other hand, the work of Cremona-Meteyard and colleagues (1992) produced results that are inconsistent with Bate et al.'s (2001) study. They also examined TBI patients' ability to orient visual attention. Their results suggest that the TBI and control groups do not differ significantly in response time. However, they did find an impaired ability in the TBI group in their ability to covertly shift attention to a cued location. In another study by Van Donjekaar et.al (2003), spatial and temporal attention in TBI patients were measured. They concluded that participants with mTBI were slower overall than controls in reacting to target appearance. They attributed the longer response time (RT) to slowness in orienting attention to the target and difficulty resolving conflict within the target configuration.

In another study by Whyte, Brieb-Neff, Gantz & Polansky (2006), sustained attention was measured in TBI subjects using the Sustained Attention to Response Task

(SART). This task differs from traditional vigilance tasks by being fairly short (4.3 min) and requiring very frequent responses. The SART presents 225 digits at the center of a computer screen in random order and requires the subject to press a response key in response to every digit except "3." When a subject does not respond to a "3" stimuli, it is thought to reflect a lapse in attention, thus reflecting an impairment in sustained attention. They found no significant difference between TBI and controls in errors of the SART. However, they did find that RT was significantly slower in those with a TBI. The authors indicate possible confounding effects in this study because they tested controls weekly over 2 weeks and TBI participants over 6 weeks. They acknowledge that their study design may have affected the two study groups. When examining the empirical evidence reported from these studies, questions remain regarding possible attention and/or processing speed deficits in TBI patients.

Attentional Networks and Neuroanatomical Correlates of PTSD

Leskin and White (2007) recently reported a study on three aspects of attentional network efficiency in a civilian subject cohort with PTSD symptoms. They used the attentional network task (ANT) initially developed by Fan et al. (2002). They found that participants with PTSD are slower in responding to incongruent flankers, but not congruent flankers. These results suggest that PTSD subjects are specifically impaired in inhibiting irrelevant information (i.e., distracting flankers) and, overall, exhibit specific deficits in the executive attentional network. These impairments will influence complex processing needs in real-world situations that may be accompanied by environmental distracters. Other studies have suggested that a decrease in PFC activation might contribute to a lower inhibition of amygdala reactivity and an increase in the fear

response exhibited in PTSD (Rauch et al., 2003).

PTSD is a common psychiatric disorder in individuals who have experienced extreme trauma. Many studies focus on the neuropsychiatric manifestations of PTSD in war veterans. However, in this population there are high levels of comorbidity of psychiatric, neurologic, and substance abuse which may influence quantitative results on attention and concentration. In a study by Jenkins and colleagues (2000), they examined neuropsychological functioning of attention and concentration among female rape survivors with PTSD. They used this cohort because of the comparatively low rates of comorbidity associated with this population. In measuring selective attention, they used the Posner Visual Selective Attention Task to measure covert shifting of attention (Jenkins et al., 2000). This task differs from Posner's ANT because it focuses on the ability to orient attention from a central fixation point to a cue either above, below, left, or right of the fixation point. The objective of this task is similar to the orienting task presented in the original ANT. They found that women with PTSD displayed no impairments in shifting attention to detect a visual target. They also examined sustained and focused attention through the administration of the Continuous Performance Test (CPT) and the Digit Symbol subtest of the WAIS-R. They found significant differences in sustained and focused attention between the PTSD and non-PTSD groups. The PTSD group made more omission errors on the CPT and repeated fewer total digits correctly than the non-PTSD group. Jenkins et al.'s (2000) study is also noteworthy in that they address the interaction of PTSD and depression on attention. Because a diagnosis of PTSD is very often associated with depression, they also administered the Beck Depression Inventory (BDI). Their results produced very weak correlations between BDI

scores and sustained attention. This suggests that depression plays only a minor role in sustained attention for women with PTSD.

Attention, learning, and memory performances of Vietnam veterans were examined in a study by Vasterling et al. (2002). It is important to note that the volunteers were not included in their study if they reported a history of head trauma or loss of consciousness greater than 15 minutes. They measured attention by examining four components: 1) *focus-executive,* the ability to focus on and respond appropriately to cues selected from an array, measured by letter cancellation omissions and Stroop Test; 2) *sustain,* the vigilance over time of focused attention, measured by Continuous Performance Test; 3) *shift,* the capacity to change the focus of attention, measured by Wisconsin Card Sorting Test; and 4) *encode,* the ability to register, recall, and manipulate cues mentally, measured by WAIS-R Digit Span. Their results suggest that Vietnam veterans with PTSD differed significantly from those without PTSD on tasks of attention on abilities of focused and sustained attention. They found that veterans with PTSD diagnoses responded to fewer correct CPT stimuli and performed less efficiently on the WAIS-R Digit Span subtest. However, PTSD veterans did not differ from non-PTSD veterans on shift tasks. Similar to Jenkins et al.'s (2000) study, Vasterling et al. (2002) conclude that PTSD sufferers exhibit deficits on tasks assessing sustained attention. They attribute this weakness to disordered arousal and dysfunction of the prefrontal cortex. Vasterling et al.'s (2002) study also examined the influence of depression, psychoactive medication, and prior alcohol use on cognitive performance. Their results indicate that PTSD-related deficits on cognitive tasks do not appear to be a function of depression, psychoactive medication usage, nor history of alcohol-use disorders. This

data suggests that deficits in neurocognition in PTSD are independent of confounding influences on cognitive functioning.

"Approximately 90% of individuals with either a mild traumatic brain injury or cerebrovascular accident (CVA) manifest some type of oculomotor dysfunction after the acute phase of care" (Ciuffreda et al., 2008). In Ciuffreda et al.'s (2008) investigation on the symptoms and signs of visual problems manifested a civilian cohort with mTBI, the most common visual complaints of oculomotor deficits were reading difficulty, eyestrain, diplopia, and headaches. The most common signs of visual dysfunction were reduced near point of convergence, abnormal Developmental Eye Movement (DEM) test results and reduced near convergence range. Their results indicate a wide range of vergence, versional, and accommodative problems. The authors state that these visual deficits, if not corrected, can exert a negative influence on an individual's overall quality of life. For example, watching television, reading the newspaper, or even driving a car are difficult for subjects suffering from these ocular problems. Ciuffreda et al. (2008) also suggest that these oculomotor deficits can also impede one's overall rehabilitative progress. For instance, "presence of accurate and steady fixation as well as efficient saccadic tracking is required in many aspects of cognitive therapy, such as completing a complex visual search matching task" (Ciuffreda et al., 2008). They conclude that vision therapy assessment should be taken into account to allow for better control of the therapeutic components and case management.

In an on-going study of visual characteristics of personnel diagnosed with mTBI related to their service in Iraq and Afghanistan, research indicates a high rate of binocular vision problems such as diplopia, blurry vision, and reading problems (Goodrich, 2008).

Dr. Gregory Goodrich at the Palo Alto VA Health Care System is currently conducting a comparison study on visual dysfunction in mTBI and PTSD. In Goodrich's study he has focused on two groups: 1) inpatient veterans and service members who have sustained visual impairments associated with life-threatening polytrauma injuries and 2) outpatients who have sustained visual dysfunctions associated with mTBI. His preliminary data suggests that while these two groups differ in terms of the severity of their injuries, they both share two common features: 1) the most common cause of injury is a blast event and 2) both groups have sustained a mTBI. His initial analysis proposes that both groups have rates of blindness, visual impairment, or visual dysfunction appear to occur at rates higher than in prior war-related injuries. His research indicates that, in addition to mental and physical injuries, damage to the visual system within the brain can cause significant functional impairments. Consistent with Ciuffreda et al.'s (2008) clinical observations, Goodrich states that addressing these visual dysfunctions during rehabilitation and therapy can assist rehabilitative efforts and can help families and friends realize the problems their loved ones are facing. A problem that Goodrich addresses is that these individuals are also usually diagnosed with PTSD. While there is not a great deal of research to date on visual effects of PTSD alone, preliminary evidence seems to indicate that PTSD might manifest vision symptoms similar to those of individuals with mTBI. However, few studies have addressed the visual problems associated with the polytrauma population returning from Iraq and Afghanistan.

CLINICAL IMPLICATIONS OF RESEARCH REGARDING A DUAL DIAGNOSIS OF TBI AND PTSD

The current wars in Iraq and Afghanistan have exposed American military to prolonged periods of combat stress and explosive hazards. Many providers are faced with the challenges of treating these veterans that have shared impairments, most specifically, mTBI and PTSD when they return to civilian life. Recent reports suggest that the rate of PTSD in returning OIF/OEF veterans is similar to the rate of TBI and that 37 to 44 percent of those with a possible TBI may also have PTSD (Hoge et al., 2008). Since 1989, the VA has operated inpatient and outpatient clinics to treat PTSD and is now the largest provider of PTSD services in the United States (Sayer, Rettmann, Carlson, Bernardy, Sigford, et al., 2009). In 2005, the VA developed the "Polytrauma Network System of Care (PNS)" to rehabilitate OIF/OEF Veterans with TBI. However, the VA-specialized PTSD programs and the PNS are separate regarding treatment and care. Currently, there is little data to guide in the VA diagnosis, treatment, and management of PTSD and TBI in OIF/OEF Veterans. Although research indicates that the majority of mild TBI cases are resolved within weeks or months (McCrea et al., 2003), some individuals continue to experience postconcussive symptoms years after the blast event. Regarding care and treatment for our service-members that have suffered a dual impairment, research is needed to assess the overlapping conditions that these impairments cause. The diagnostic challenges are due to many varied and nonspecific symptoms similar to TBI and PTSD such as concentration difficulties, irritability, impaired decision making abilities, and memory problems (Van Boven et al., 2009). In a study by Sayer et al. (2009), providers were interviewed across the nation to assess the

areas that would best facilitate clinical diagnosis and treatment with these individuals. They found that there was a remarkable consensus across providers in PNS and PTSD teams with regard to challenges of determining whether a patient's current symptoms result from a mTBI or PTSD or both. Another clinical implication of attentional research with TBI and PTSD is that an accurate diagnosis is imperative for effective treatment. Cognitive processing therapy, CPT, is currently the therapy of choice for treatment of PTSD at the VA. Veterans with a dual diagnosis of TBI and PTSD may find it more difficult to engage in this form of treatment. The therapy is very structured and not as flexible for Veterans with a dual impairment. The cognitive component of CPT relies heavily on homework completion which may also be strenuous for TBI+PTSD Veterans. Other forms of therapy may be recommended for treatment of TBI+PTSD Veterans. For example, prolonged exposure, PE, may be associated with better treatment participation and outcomes compared with CPT "because it is not so heavily reliant on memory" (Sayer et al., 2009). Also, the presence of TBI and PTSD, "makes everything go much more slowly, there is a lot more repetition," as one provider stated from Sayer's study (2009). There is currently a high demand for research in TBI and PTSD especially regarding the medical and mental health of our Veterans returning from their tours in OIF and OEF. There is also a lack of attentional research within this military cohort. The results of this study will help in the clinical assessment, diagnosis, and treatment options for these individuals by providing information on the attentional mechanisms and neurological origins that may be effected by the dual impairment of TBI and PTSD.

STATEMENT OF THE PROBLEM

As described earlier, many troops and veterans are returning from their tours in Iraq and Afghanistan suffering from mTBI and PTSD. There is an increasing demand for research needed to help assess the mental health of members of the armed services who have served in these tours. However, there is little existing research that investigates the problems and complaints that these disorders share. The purpose of this study was to determine what types and levels of visual and attentional deficits might be evident among polytrauma populations, and potentially provide new insights into the possible neuroanatomical origins of these deficits. The results of this study will help to establish quantitative profiles of visual and attentional performance in those with isolated PTSD diagnosis, versus those with comorbidity of PTSD and TBI. Ideally, a cohort of patients with TBI alone was desired for participation in this study; however, this was not possible due to the lack of veterans with a sole diagnosis of TBI. Still the comparison of patients with isolated PTSD versus those with PTSD and TBI may provide clues to the contribution of TBI to visual and attention problems.

METHOD

Participants

A total of 45 combat veterans between the ages of 19-45 who have served in Operation Iraqi Freedom (OIF) and/or Operation Enduring Freedom (OEF) were recruited from a southeastern military medical center to participate in this study. The participants were grouped according to diagnosis: 1) 15 who have been diagnosed with PSTD without mTBI, 2) 15 who have been diagnosed with both mTBI and PSTD, and 3) 15 age-matched combat veteran controls who have neither diagnosis. The participants had no history of a previous ocular disease or ADHD (prior to military deployment) nor active drug/alcohol abuse or dependencies. The participants were also capable of giving informed consent. The participants were screened by examining the patient's medical record in the Computerized Patient Record System (CPRS) to determine which candidates best met inclusion criteria.

Instruments

The lateralized attention network task (LANT) is a modified version of the original attention network task (ANT) developed by Fan et al. (2002). This task has been proven to be a useful tool in attention research because of its simplicity and reliability. Unlike the ANT, this task has been lateralized by rotating the cues and associated flankers 90 degrees, thus presenting the stimuli to the left or right of the fixation cross instead of above or below. The targets are preceded by one of 4 cue types: no-cue, valid spatial cue (presented at the location of the upcoming target), central cue, and double cue (presented at the two possible locations of the target). The subject was instructed to

fixate on a centrally located crosshair in the middle of the display screen, and remain alert to the presentation of the spatial cues and target. Upon presentation of the target, the subject's task was to respond as rapidly as possible as to the orientation of the target (up or down). Each target was accompanied by flanker arrows.

Following the standard approach (Fan et al., 2002) three metrics were calculated to measure the efficiency of the *Alerting, Executive,* and *Orienting* networks. The efficiency metric for the *Alerting* network was calculated by subtracting the mean Response Time (RT) for the center conditions from the no-cue conditions. The *Orienting* efficiency metric was determined by subtracting the mean RT for the spatial cue condition from the mean RT for the center cue condition. And the *Executive* metric was calculated by subtracting the mean RT for congruent flanker trials from mean RT of incongruent flanker trials. In summary, the following formulas were used to calculate the metrics for the efficiency of each attention network:

$$\textit{Alerting effect} = RT_{\textit{no cue}} - RT_{\textit{center cue}}$$

$$\textit{Orienting effect} = RT_{\textit{center cue}} - RT_{\textit{spatial cue}}$$

$$\textit{Executive (Conflict) effect} = RT_{\textit{incongruent flanker}} - RT_{\textit{congruent flanker}}$$

Apparatus and Stimuli

Stimuli was presented on a Dell Inspiron 1525 computer attached to a 19" 1703FPs Dell monitor with a refresh rate of 60 Hz and a resolution of 1280 x 1024 pixels. Participants viewed the screen from a distance of 65 cm and responses were collected from a Dell keyboard placed in front of the subject at midline.

Stimuli consisted of a row of five vertical black lines, with arrowheads pointing upward or downward, against a white background. The central target arrow was flanked above and below with 2 arrows either in the same direction (congruent condition), or in the opposite direction (incongruent condition), or by line segments with no arrow head (neutral condition). The duration of the fixation ranged between 800 and 1200 msec and were randomly determined on each trial. The duration of the spatial cues (an asterisk symbol) was 150 msec, and the target stimulus duration was 300 msec. Each participant was administered a practice trial of 12 cues and 2 experimental blocks of trials lasting approximately 8 minutes each. A diagram of the LANT stimuli is provided in Figure 1.

Procedure

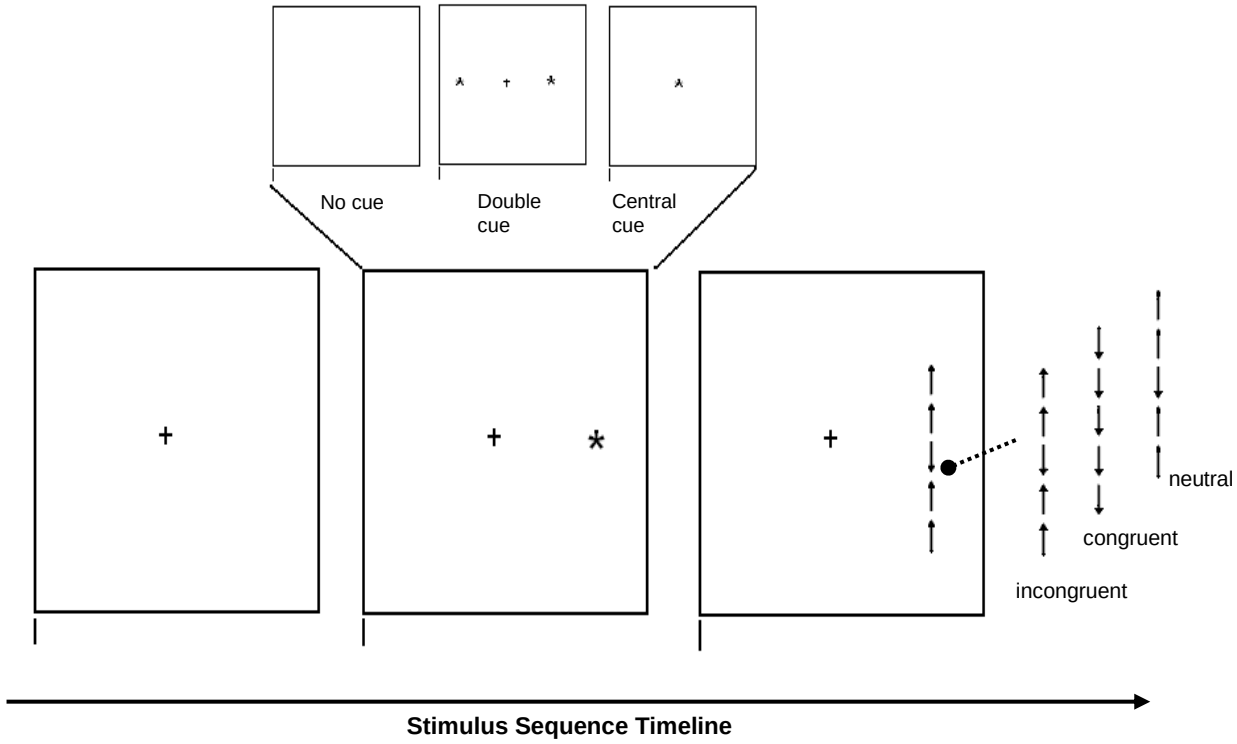
Before the vision and attention screens, the subject had ample opportunity to read and sign the consent form (Appendix C) and HIPPA authorization for medical record release (Appendix D) and to ask any additional questions about the study. During the visual screening process, the subject's visual acuity was measured using Snellen notation, and intraocular pressure was taken by air tonometry. The participant's current prescription was assessed by lensometry and documented. Measures of color vision, pupil reaction, spatial orientation, binocular testing, and reading testing were also documented for the visual screen. All results from the visual screen was first recorded on paper and then entered in CPRS on a template. The paper was placed in a security container for shredding after the results are recorded in the Research Folder on the G-drive and CPRS.

For the attention screen, participants were first exposed to a 12-trial practice block in which they received feedback for their accuracy. This was followed by the

experimental block of the LANT (96 trials). The practice block lasted approximately 30 seconds and the experimental trial lasted approximately 8 min. Between experimental blocks the participants were allowed a break to rest their eyes. The duration of time expected for patient participation was around 1 hour.

Analysis

The median response time on accurate trials and accuracy scores were the main dependent variables of interest. Response time was defined as the length of time from the appearance of the target arrow to when the corresponding arrow key was pressed on the keyboard. Accuracy scores were defined as the percentage of trials within a condition that the subject completed correctly. Each of the efficiency metrics of the LANT were measured separately, using a 2 (Visual Field: LVF, RVF) X 3 (Diagnostic group: PTSD, mTBI + PTSD, and control) repeated measures ANOVA. When computing the effects associated with the Alerting, Orienting, and Executive components of attention, the paradigm by Fan et al. (2002) was followed.



Variable length **fixation interval** (500-1200msec)

Cue is presented (No Cue, Central Cue, Double Cue, Single Cue) -- lasts 100 msec. The single cue condition is shown in timeline above

Target Interval. Central target arrow can point up or down, and flanker arrows can be neutral, incongruent, or congruent with Target arrow (see above right)

Figure 1. Visual Stimuli and Timeline of the ANT Stimulus Sequence

RESULTS

The LANT is a computerized methodology which measures the speed and accuracy of attentional performance. Mean response time (RT), accuracy, and the RT standard deviations obtained in this study are listed in Table 1 and in Figures 2-4. RT standard deviation measures the intra-subject variability of response time across the 96 trials of the LANT. Patient Group had main effects on RT, $F(2, 42) = 7.92$, $p = .001$, performance accuracy, $F(2, 42) = 4.03$, $p = .025$, as well as the standard deviations for RT, $F(2, 42) = 4.16$, $p = .023$. Post hoc analyses revealed that the significant effects were attributable to the differences between the TBI+PTSD group and the other two subject groups. No significant differences were found between the PTSD and Control group.

Table 1
Average Response Times, Accuracy Scores, and Response Time Standard Deviations across Groups (sec)

	Group	Mean	
Response Time (n=45)		LVF	RVF
	TBI+PTSD	1.06	1.05
	PTSD	.75	.72
	Control	.67	.66
Percent Correct (n=45)			
	TBI+PTSD	.75	.77
	PTSD	.87	.86
	Control	.88	.89
Intra-Subject			
Response Time	TBI+PTSD	.49	.64
Standard Deviations (n=45)	PTSD	.42	.27
	Control	.22	.22

We were also interested in determining whether attentional performance might show hemispheric asymmetry in one or more of the subject groups. We therefore

performed 2 (VF: left, right) X 3 (group: TBI+PSTD, PSTD, and control) ANOVAs on each of the three attentional network metrics. Table 2 presents descriptive statistics for these metrics, broken down by Subject Group and VF.

Table 2
Mean and Standard Deviations of Attentional Metric Values (sec)

	Group	Mean (Standard Deviation)	
Alerting (n=45)		LVF	RVF
	TBI+PTSD	.10 (.25)	-.09 (.31)
	PTSD	.12 (.36)	.02 (.11)
	Control	.08 (.25)	.03 (.04)
Orienting (n=45)			
	TBI+PTSD	-.04 (.36)	.28 (.56)
	PTSD	.06 (.09)	.08 (.09)
	Control	.08 (.06)	.08 (.07)
Executive (n=45)			
	TBI+PTSD	.12 (.27)	.15(.18)
	PTSD	.09 (.15)	.09 (.09)
	Control	.06 (.09)	.08 (.07)

We found no main effects of Subject Group and VF on the network metrics. For the Alerting Network there was a trend toward a significant interaction, $F(1, 42) = 3.40$, p=.072, between Subject Group and VF. Pairwise comparisons indicated that the TBI+PTSD group (p=.05) did not show an Alerting effect (M=-.09) in the RVF indicating that the TBI+PTSD group did not benefit from a temporal cue presented to the right visual field. No significant VF X Subject Group interaction was found for the Orienting metric, $F(1, 42) = 2.39$, $p = .13$, or Executive metric, $F(1, 41) = .18$, $p = .67$.

The relatively large intra-subject RT standard deviations of the TBI+PTSD group (Table 1) indicates that these subjects on average were more variable in their attentional responses from one trial to the next, perhaps indicating lapses of attentional focus. The relatively large inter-subject variability of this group (standard deviations in parentheses

in Tables 1 and 2) seems to indicate that these subjects were also a more diverse cohort in their attentional performance, especially compared to the Control group, who performed more consistently on the attentional tasks. Contrary to our predictions, the absence of a VF X Subject Group interaction suggests that, even though the group with TBI+PTSD performed slower and less accurately, all three groups performed in a similar fashion attending to visual fields.

We also examined the response time and accuracy scored within the six cue conditions that contributed to the attentional metric values presented in Table 2. Table 3 presents descriptive statistics for these conditions. There were no main effects of Subject Group and VF on either response time or accuracy. There was a significant Subject Group X VF interaction that affected response time in the no-cue condition, $F(1, 42) = 4.01$, $p = .05$ which showed that the TBI+PTSD group took significantly longer to respond in the LVF when a pre-cue was not given. Likewise in the spatial-cue condition that contributes to the Orienting metric, a trend toward a significant interaction between Subject Group and VF was found for response time $F(1, 42) = 3.58$, $p = .06$ which indicated that the TBI+PTSD group took significantly longer to disengage attention when presented with a spatially relevant pre-cue in the LVF. Each of the conditions contributing to the Executive metric did not show significant interaction effects.

Table 3
Descriptive Statistics for the Six Conditions of the LANT (sec)

	Group	Response Time		Accuracy	
Center Cue		LVF	RVF	LVF	RVF
	TBI+PTSD	.99 (.44)	1.22 (.87)	.74 (.19)	.76 (.15)
	PTSD	.75 (.15)	.72 (.21)	.83 (.14)	.84 (.18)
	Control	.68 (.10)	.68 (.10)	.86 (.13)	.86 (.12)
Spatial Cue					
	TBI+PTSD	1.09 (.56)	1.03 (.47)	.83 (.20)	.85 (.18)
	PTSD	.74 (.21)	.66 (.18)	.93 (.12)	.89 (.21)
	Control	.61 (.08)	.61 (.06)	.93 (.09)	.95 (.11)
No Cue					
	TBI+PTSD	1.14 (.53)	1.03 (.44)	.70 (.16)	.75 (.21)
	PTSD	.84 (.30)	.77 (.15)	.88 (.13)	.88 (.09)
	Control	.71 (.09)	.69 (.09)	.88 (.12)	.87 (.16)
Double Cue					
	TBI+PTSD	1.04 (.41)	1.12 (.62)	.75 (.17)	.73 (.22)
	PTSD	.72 (.17)	.75 (.13)	.82 (.21)	.82 (.19)
	Control	.68 (.08)	.67 (.09)	.87 (.12)	.89 (.10)
Incongruent					
	TBI+PTSD	1.15 (.44)	1.12 (.48)	.59 (.23)	.62 (.23)
	PTSD	.81 (.20)	.79 (.18)	.75 (.18)	.80 (.17)
	Control	.72 (.10)	.72 (.08)	.75 (.20)	.75 (.27)
Congruent					
	TBI+PTSD	.97 (.46)	.91 (.35)	.97 (.46)	.91 (.35)
	PTSD	.72 (.13)	.70 (.11)	.72 (.13)	.70 (.11)
	Control	.66 (.09)	.64 (.08)	.66 (.09)	.64 (.08)

Prior to the study onset, we interviewed each patient by asking them various questions about problems they were currently experiencing. One of the questions was whether they had experienced any attentional problems following the traumatic event. Based on their answers, we grouped the subjects into two categories (no-complaint and complaint). When comparing the response accuracy scores of these two groups, a significant Subject Group X VF interaction was found, $F(1, 13) = 7.61$, $p = .016$, revealing that the no-complaint group performed better in the LVF while the complaint-group performed better in the RVF (Figure 5). The same pattern of performance was

observed for response times, although this was not statistically significant. Response time and accuracy scores for these two subject groups are listed in Table 4.

Table 4
Self-reported Attentional Complaints in TBI+PTSD Group and LANT Performance

		Mean (Standard Deviation)	
No attentional complaints		LVF	RVF
	Accuracy	.82 (.11)	.78 (.11)
	Response Time	1.10 (.28)	1.12 (.35)
Attentional Complaints			
	Accuracy	.70 (.19)	.75 (.21)
	Response Time	1.12 (.35)	1.00 (.64)

n=15

Vision

Prior to performing our study of attentional performance, we evaluated our subjects' eye function as measured by standard ophthalmological tests, including Snellen visual acuity, extra ocular movements, intraocular pressures, confrontation visual fields, and pupillary reactions. We found no significant differences between subject groups on these measures. The majority of the groups exhibited best corrected visual acuity of 20/20 or better using Snellen notation. No significant confrontation visual field deficits, extra ocular movements, and pupil reactions were found. These results indicate that the attentional performance differences we found between TBI+PTSD subjects and the other groups were not due to basic vision problems attributable to ocular damage.

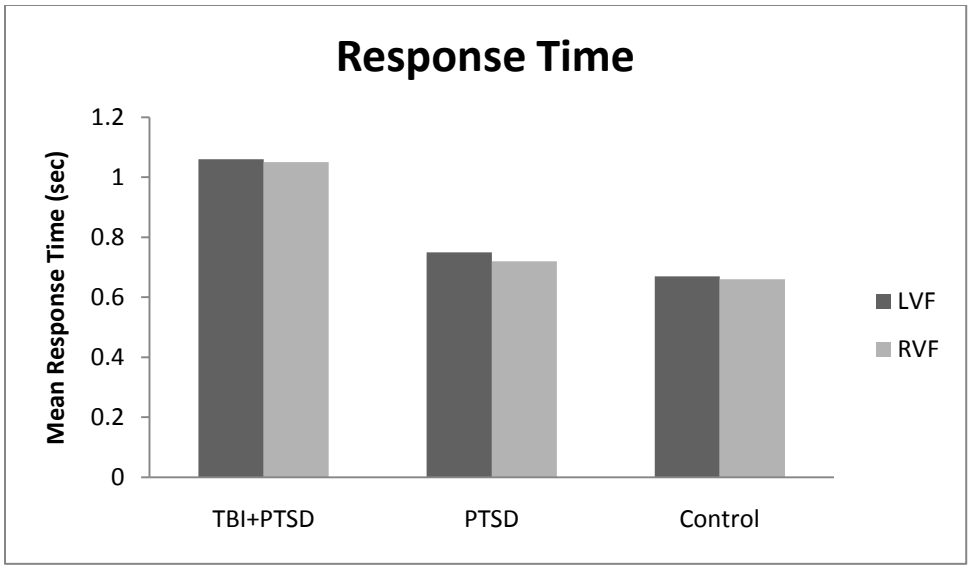


Figure 2. Mean response times of the TBI+PTSD, PTSD, and Control groups in the LANT, n=45.

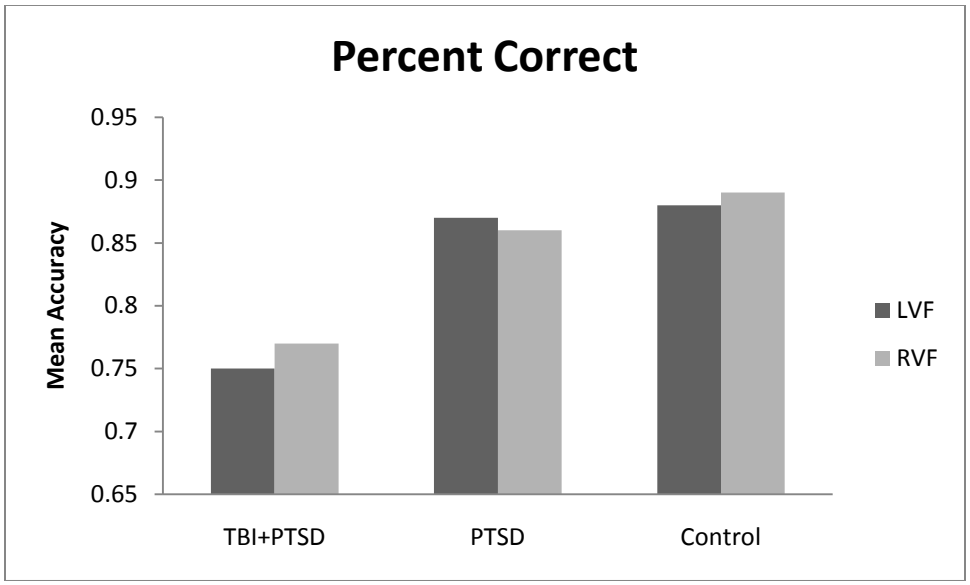


Figure 3. Mean accuracy scores of the TBI+PTSD, PTSD, and Control groups in the LANT, n=45.

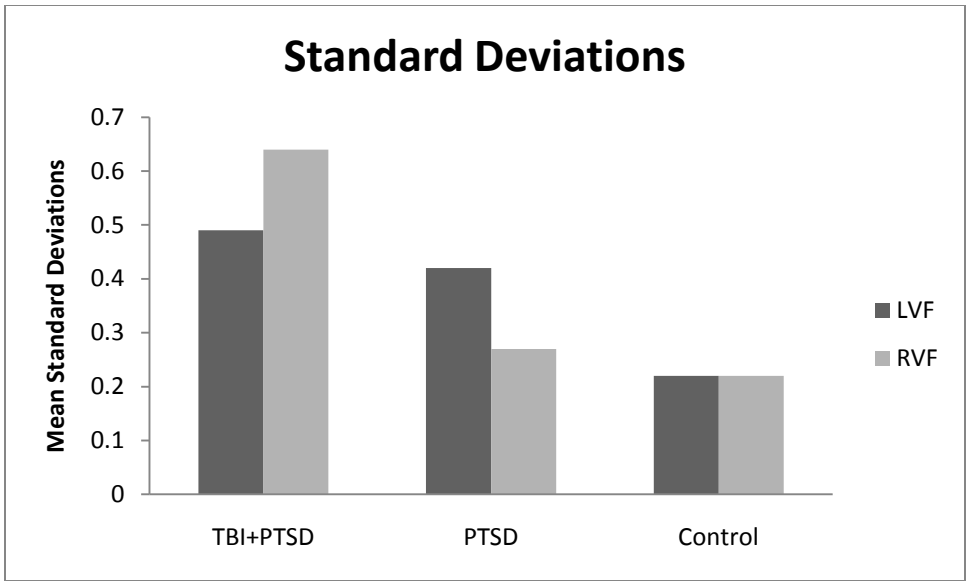


Figure 4. Mean standard deviations of the TBI+PTSD, PTSD, and Control groups in the LANT, n = 45.

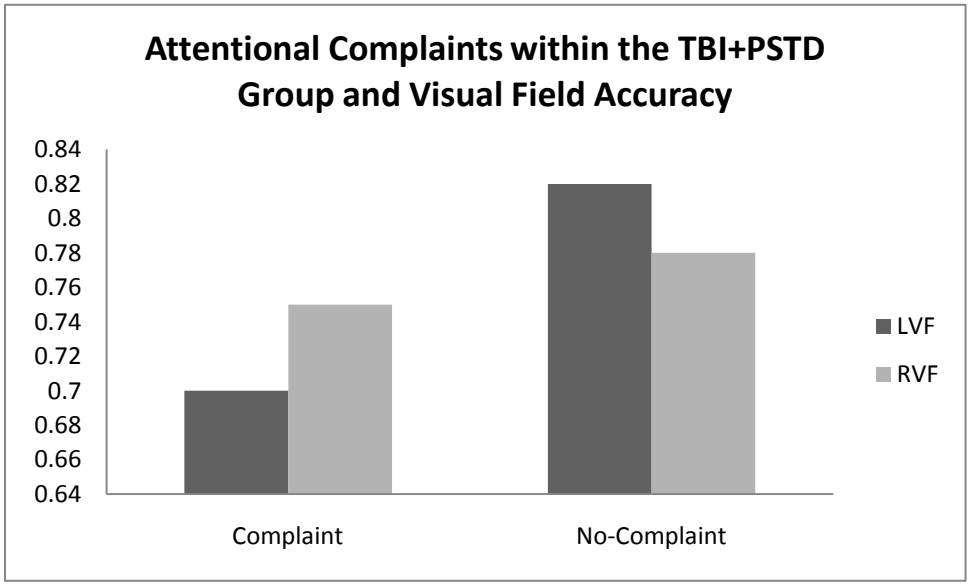


Figure 5. Accuracy regarding visual field performance for self-reported attentional complains within the TBI+PTSD group, n = 15.

DISCUSSION

With every new war, new clinical challenges are presented that lead to major advances in the understanding of pathology, diagnostic assessment, and clinical treatment of mental disorders. TBI and PTSD have been named the "invisible wounds" (Van Boven et al., 2009) of combat-related injury. Unfortunately, there are many overlapping symptoms that are common to a TBI and PTSD diagnosis that cause problems in the management of clinical care for Veterans returning from the wars in Iraq and Afghanistan. The diagnostic challenges are due to many varied and nonspecific symptoms similar to TBI and PTSD, such as concentration difficulties, irritability, impaired decision making abilities, and memory problems (Van Boven et al., 2009). Attention problems are common complaints of TBI and PTSD Veterans, but few studies of returning Veterans with these diagnoses have investigated whether these patients actually manifest attentional deficits on behavioral measures of attention. Therefore, the goal of the present study was investigate attentional performance in Veterans with TBI and PTSD using an objective behavioral measure called the Attention Network Task. This computerized visual attention task measures the speed and accuracy with which subjects can shift attention to locations in the visual field and selectively focus attention on target stimuli. Since our method selectively flashed stimuli to the right and left visual field on a given trial, hemispheric asymmetries in attentional performance were measurable.

We found little difference in response time and accuracy of attentional performance between PSTD patients and Control subjects. While other studies involving

PTSDs subjects have shown attentional deficits (Jenkins, et al., 2000; Leskin & White, 2007; Vasterling, et al., 2002), we found no major differences between military PTSD and Controls in our study. Consistent with prior studies (Bate et al., 2001; Pavlovskaya et al., 2006; Van Donjekaar et al., 2005), TBI+PTSD patients performed substantially worse than both PTSD only and Controls. However, previous literature used different cognitive measures to determine attentional performance that were similar to Fan et al's (2002) Attention Network Task while we utilized a model that was designed to measure hemispheric asymmetries in attentional performance. We observed a great deal of variability within the TBI group. Some TBI patients performed equal to or better than the Control group as a whole while others performed substantially worse. We speculate that this high variability might be related to the large differences associated with traumatic brain injury. These differences include size of blast, proximity of blast, type of blast, and length of time since the injury.

The Intra-subject variability of TBI patient responses was also substantially higher than the PTSD and Control Groups (see Table 1). This perhaps indicates that they had trouble maintaining attentional focus and, as a result manifested substantial lapses of attention leading to large variability in response times. The significantly slower and less accurate attentional performance of TBI patients, and their substantially more variable response times, might be related to reduced speed of information processing thought to be caused by diffuse axonal injury (Madigan, DeLuca, Diamond, Tramontano, & Averill, 2000).

The no-cue condition of the alerting network revealed significantly slower response times for the TBI+PTSD group. The alerting component involved in this

condition measures the ability to use a pre-cue that provides information about when a response should occur. In the no-cue condition, subjects are not assisted by the presence of either temporal or spatial cues, so they must rely on their own attentional abilities to initiate and execute a shift of attentional focus. The results of our study suggest that TBI subjects performed substantially worse in this condition. The TBI subject group took significantly longer to respond to cues in the LVF, indicating a deficit in the alerting component of attention in mTBI. This perhaps indicates an unstable attentional system and an inability to sustain alertness and arousal. More specifically, the noradrenergic system arising from the locus coeruleus in the brainstem (Sturm et al., 1999) may be affected from a mTBI caused by a blast event.

The Orienting component of attention involves the ability to spatially disengage the focus of attention from one spatial location and shift to another location. It has been found in numerous studies that when a spatial cue to target location is presented just prior to the onset of the target stimuli, response times are faster than without a spatial cue, presumably because the respondent is able to covertly disengage and shift attention to the target location prior to its appearance, thus speeding the analysis of target information. In the spatial cue condition of our study, we found that the TBI group took significantly longer and was less accurate than PTSD and Control groups, presumably indicating they were less efficient in disengaging and shifting spatial attention. Consistent with prior studies (Bate et al., 2001; Madigan et al., 2000; Van Donjekaar et al., 2005), our results suggest that TBI affects the time and accuracy at which to search for a target and orient attention in space. We found that the TBI group took significantly longer in responding to cues in the LVF, perhaps indicating a RH deficit. The brain areas involved in the

searching and disengaging of attention that may be affected by mTBI are the cingulate gyrus and the dorsomedial and ventrolateral pre-frontal cortex (Nobre et al., 2004). Corbetta et al. (2002) have shown that the disengage function of attention activates the parietal lobe, more so in the right hemisphere than the left. This is consistent with the LVF (RH) orienting deficit found in our TBI patients.

Pavolvskaya and colleagues (2006) studied hemispheric visual attentional asymmetry in patients with TBI using an experimental paradigm similar to Fan et al.'s (2002) method but using five visual patterns presented selectively to the LVF or RVF. Pavolvskaya et al.'s (2006) study suggested that TBI patients exhibit a significant asymmetry in performance in the Orienting network; more specifically, they were less efficient at shifting their visual attention to the LVF. We observed the same pattern in our study, in so far as the metric measuring Orienting efficiency was substantially smaller in the LVF than RVF for TBI patients. We found a near significant interaction (p=.06) in the spatial cue condition which was attributable to a LVF deficit in response time for our TBI group. The lack of performance in the LVF by TBI patients suggest that right hemisphere, specifically right parietal areas, are most susceptible to brain injury.

In a study involving patients who have suffered a concussion, Van Donkelaar and colleagues (2005) measured attentional deficits utilizing the Attention Network Task (ANT). Their results suggested that the Orienting and Executive components of attention were the most susceptible to the effects of concussion while the Alerting component remained intact. In contradiction with their study, we found a slight trend toward significance in the Alerting Network (p=.07), which indicated less efficient shifting of attention to temporal cues for TBI patients. They also found overall slower response

times and poorer accuracy for TBI patients which was similar to the results of our current study.

Generally, we did not find strong evidence for hemispheric asymmetries in attentional performance in any of our subject groups. However, nearly half of our TBI cohort self-reported attentional problems in everyday activities in their pre-experiment interview. When we compared performance on our behavioral measures of attention between those patients reporting attentional problems versus those who did not, we found an interesting hemispheric asymmetry. Patients reporting attention problems performed significantly worse in the LVF compared to patients not reporting attention problems, suggesting a right hemisphere attention deficit. These results are consistent with Poynter et al.'s (2010) study, which showed that normal subjects who self-reported relatively high levels of attention problems on the Conner's ADHD scale performed significantly worse on two behavioral measures of attention when stimuli were presented in the left versus right visual field. This showed up most prominently in the condition where spatial cues were present, indicating that deficits in Orienting attention to the LVF (RH deficit) tend to correlate with self-rated attention problems. This RH deficit has been documented in various studies of ADHD, and right parietal lobe damage is widely documented to produce more severe attentional neglect than left parietal lobe damage (Corbetta et al, 2008, Heilman et al., 1993; Posner et al., 1990). Our results and those of Pavlovskaya et al. (2006) provide initial evidence that at least subgroups of TBI patients might have dysfunctions of the RH parietal lobe and prefrontal cortex based on brain imaging studies of anatomical loci involved in the orienting of visual attention (Corbetta et al., 2002).

It is important to note that blast-related mild TBI does not manifest observable neuroanatomical lesions because injury is diffuse and does not selectively injure a specific region of the brain. Also, combat-related mTBI might be considered different from sports-related or fall/accident-related head injury because of the context of the injury (e.g., blast versus car accident) and the damage of injury (e.g., diffuse versus localized). Because of these reasons, a challenge is presented when making the proper diagnosis and treatments for our servicemen who have been exposed to a blast event. Can you adequately compare civilian TBIs and combat-related TBIs? The literature cited throughout this study used civilian TBIs. Our study is unique because it is one of the first to measure attentional performance in military TBIs. The results of our study suggest that while military TBIs are very different than civilian TBIs, similar cognitive deficits were observed regarding attentional performance. Our results are one of the first to provide converging evidence for some of the cognitive deficits associated with mTBI.

Limitations of Study and Implications for Future Research

The large variability in attentional performance within the TBI groups can be explained by several factors. First, premorbid functioning is not known within this patient population. These Veterans may have displayed slower and less accurate attentional performance prior to their blast event. Second, the exact timeline regarding the changes in neuropathology recovery after a TBI is unclear. Research suggests that the progression of recovery may range from days to months after exposure to a blast event (McCrea et al., 2003). However, some symptoms may remain years after the event. Within our TBI sample, exposure to the blast event ranged from months to years prior to

testing. This range of time difference may help to explain the variability exhibited in our study among attentional performance within this patient population.

The severity of the blast event also needs to be considered when working within this population. The Department of Veterans Affairs and Department of Defense define blast events as primary, secondary, tertiary, and quaternary. Blast events can occur from the overpressure post explosion or to direct impact to the head. The etiology of the injury also ranges from IEDs, mortar, shrapnel, grenade, and vehicular. Further investigation that distinguishes attentional performance between the types of head injury is needed. TBI patients are also often prescribed certain medications that help alleviate the side effects common to injury. For example, Topamax is often given for relief of migraines. It is not known if these medications are known to affect attention.

Although a diagnosis of ADHD was an exclusion criterion for our study, three of the 15 TBI patients were recently diagnosed with an attentional impairment. These patients observed no attentional problems prior their blast event. Clinical implications need to be considered when diagnosing these individuals with ADHD. Future research is needed to investigate the attentional complaints that differentiate TBI from ADHD for optimal rehabilitation and medical care.

We also found that there is large intra-subject variability among the TBI group in the performance over the course of the LANT, perhaps indicating that the TBI patients in our study suffered more severe lapses of attention, or were more easily distracted than the PTSD or Control subjects. Whyte et al. (2006) used a Sustained Attention to Response Task (SART) and found an overall slower response in those with a TBI. Segalowitz, Dywan, Unsal (1997) examined the variability found in attention tasks by TBI patients

and found that it is the variability in response time that is the most valid measure of the ability to assign and sustain attention. They concluded that TBI patients exhibit an inability to maintain focus throughout the duration of attentional tasks. Their results are similar to the higher intra-subject variability we observed regarding slower response times on behavioral attention tasks. Future studies that examine attentional performance of focused and sustained attention may reveal significant findings in this area.

Conclusions

We found strong evidence that TBI+PTSD subjects performed substantially worse on behavioral measures of attention. Although we were unable to reproduce findings that support a hemispheric asymmetry in the three attentional networks, we found that the TBI group took significantly longer in responding to spatial cues in the LVF, perhaps indicating a RH deficit. The variability in the data produced from TBI+PTSD Veterans also seems to indicate large individual differences in injury, which in turn may relate to the severity and time of the blasts. Within our military cohort of TBI patients, blasts occurred as late as 2003 with the most recent injury in 2008. The extent of the head injuries was also very different. Two of the 15 TBI patients we tested experienced penetrating head injuries, while the others did not experience extensive injury to the head. We conclude that TBI does cause impairment in attentional response and accuracy. Our results also indicate that TBI patients who self-report relatively high levels of attention problems in everyday activities performed significantly worse on behavioral measures of attention when orienting to the LVF, indicating a RH deficit not present in the control group.

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Appendix A

Appendix A

3 Question DVBIC TBI Screening Tool
Instruction Sheet

Purpose and Use of the DVBIC 3 Question TBI Screen

The purpose of this screen is to identify service members who may need further evaluation for mild traumatic brain injury (MTBI).

Tool Development

The 3 Question DVBIC TBI Screening Tool, also called The Brief Traumatic Brain Injury Screen (BTBIS), was validated in a small, initial study conducted with active duty service members who served in Iraq/Afghanistan between January 2004 and January 2005.

Schwab, K. A., Baker, G., Ivins, B., Sluss-Tiller, M., Lux, W., & Warden, D. (2006). The Brief Traumatic Brain Injury Screen (BTBIS): Investigating the validity of a self-report instrument for detecting traumatic brain injury (TBI) in troops returning from deployment in Afghanistan and Iraq. *Neurology, 66*(5)(Supp. 2), A235.

Who to Screen

Screen should be used with service members who were injured during combat operations, training missions or other activities.

Screening Instructions

Question 1: A checked **[√]** response to any item A through F verifies injury.

Question 2: A checked **[√]** response to A-E meets criteria for a positive (+) screen. Further interview is indicated. A positive response to F or G does not indicate a positive screen, but should be further evaluated in a clinical interview.

Question 3: Endorsement of any item A-H verifies current symptoms which may be related to an MTBI if the screening and interview process determines a MTBI occurred.

Significance of Positive Screen

A service member who endorses an injury [Question 1], as well as an alteration of consciousness [Question 2 A-E], should be further evaluated via clinical interview because he/she is more highly suspect for having sustained an MTBI or concussion. The MTBI screen alone does not provide diagnosis of MTBI. A clinical interview is required.

For more information contact:
Telephone: 1-800-870-9244 Email: info@DVBIC.org Web: www.DVBIC.org

3 Question DVBIC TBI Screening Tool

1. Did you have any injury(ies) during your deployment from any of the following? (check all that apply):

A. ☐ Fragment
B. ☐ Bullet
C. ☐ Vehicular (any type of vehicle, including airplane)
D. ☐ Fall
E. ☐ Blast (Improvised Explosive Device, RPG, Land mine, Grenade, etc.)
F. ☐ Other specify: _____

2. Did any injury received while you were deployed result in any of the following? (check all that apply):

A. ☐ Being dazed, confused or "seeing stars"
B. ☐ Not remembering the injury
C. ☐ Losing consciousness (knocked out) for less than a minute
D. ☐ Losing consciousness for 1-20 minutes
E. ☐ Losing consciousness for longer than 20 minutes

NOTE: Endorsement of A-E meets criteria for positive TBI Screen

F. ☐ Having any symptoms of concussion afterward (such as headache, dizziness, irritability, etc.)
G. ☐ Head Injury

NOTE: Confirm F and G through clinical interview

H. ☐ None of the above

3. Are you currently experiencing any of the following problems that you think might be related to a possible head injury or concussion? (check all that apply):

A. ☐ Headaches
B. ☐ Dizziness
C. ☐ Memory problems
D. ☐ Balance problems
E. ☐ Ringing in the ears
F. ☐ Irritability
G. ☐ Sleep problems
H. ☐ Other specify:_____

Schwab, K. A., Baker, G., Ivins, B., Sluss-Tiller, M., Lux, W., & Warden, D. (2006). The Brief Traumatic Brain Injury Screen (BTBIS): Investigating the validity of a self-report instrument for detecting traumatic brain injury (TBI) in troops returning from deployment in Afghanistan and Iraq. *Neurology, 66*(5)(Supp. 2), A235.

For more information contact:
Telephone: 1-800-870-9244 Email: info@DVBIC.org Web: www.DVBIC.org

Appendix B

Department of Veterans Affairs
Veterans Health Administration
Washington, DC 20420

VHA DIRECTIVE 2007-013

April 13, 2007

SCREENING AND EVALUATION OF POSSIBLE TRAUMATIC BRAIN INJURY IN OPERATION ENDURING FREEDOM (OEF) AND OPERATION IRAQI FREEDOM (OIF) VETERANS

1. PURPOSE: This Veterans Health Administration (VHA) Directive establishes policy and procedure for screening and evaluation of possible traumatic brain injury (TBI) in Operation Enduring Freedom (OEF) and Operation Iraqi Freedom (OIF) veterans.

2. BACKGROUND

a. TBI is a common form of injury in service men and women serving in OEF and/or OIF. Details on the screening and management of TBI can be found in the Employee Education System Veterans Health Initiative (VHI) module (see par. 5). As experience with this condition in OEF and OIF veterans accumulated, it became clear that screening for possible TBI in OEF and OIF veterans could contribute to ensuring that cases are identified and treatment implemented.

b. In response to this need, VHA established a task force including members with expertise in Physical Medicine and Rehabilitation, Neurology, Psychiatry, Psychology, Primary Care, Prevention, and Medical Informatics to develop a screening tool and evaluation protocol. Although TBI is a significant public health problem, currently there are no validated screening instruments accepted for use in clinical practice. Therefore, the task force reviewed existing literature on screening for TBI, examined the efforts of individual military Medical Treatment Facilities and Department of Veterans Affairs (VA) Medical Centers that had implemented TBI screening locally, consulted with the Defense and Veterans Brain Injury Center (DVBIC), and considered data on the natural history of TBI. Based on these efforts, the task force developed a screening instrument to assist in identifying OEF and OIF veterans who may be suffering from TBI, and a protocol for further evaluation and treatment of those whose screening tests are positive.

c. A national clinical reminder, VA-TBI Screening, was built incorporating this screening instrument. The reminder has several elements, as follows:

(1) The first step of the reminder is to identify possible OEF and/or OIF participants based on whether date of separation from military duty or Active Duty status occurred after September 11, 2001. Similar to the OEF/OIF Post-Deployment Screening Reminder, the initial questions address location of deployment. The definition of OEF and/or OIF participant is the same as used for the OEF/OIF Post-Deployment Screen with OEF which includes service in: Afghanistan, Georgia, Kyrgyzstan, Pakistan, Tajikistan, Uzbekistan, the Philippines, and an "other" category; and OIF which includes service in Iraq, Kuwait, Saudi Arabia, Turkey, and an "other" category. The screening is done once for all individuals who report deployment to

OEF-OIF Theaters, to be repeated if the date of separation has changed due to repeat deployment. The reminder recognizes if screening was completed prior to the most recent date of separation.

(2) The reminder then asks whether the patient has already been diagnosed as having TBI during OEF or OIF deployment. Positive answers can be based on patient or caregiver self-report or health records from VA or non-VA sources. Positive answers lead to an option to order a referral for follow-up if the patient does not have current follow-up and wants assistance.

(3) For those who confirm OEF or OIF deployment and do not have a prior diagnosis of TBI, the instrument proceeds using four sequential sets of questions. If a person responds negatively to any of the sets of questions, the screen is negative and the reminder is completed. If the patient responds positively to one or more possible answers in a section the next section will open in the reminder to continue the screening process. The four sections are:

(a) Events that may increase the risk of TBI.

(b) Immediate symptoms following the event.

(c) New or worsening symptoms following the event.

(d) Current symptoms.

(4) If a person responds affirmatively to one or more questions in each of the four sections, the screen is positive and arrangements for further evaluation is offered. The reminder prompts the user to place a consult for further evaluation, or documents refusal.

d. Not all patients whose screen is positive have TBI. It is possible to respond positively to all four sections due to the presence of other conditions, such as: Post-traumatic Stress Disorder (PTSD), cervico-cranial injury with headaches, or inner ear injury. Therefore, it is critical that patients not be labeled with the diagnosis of TBI on the basis of a positive screening test. Patients need to be referred for further evaluation.

e. The VHA task force also developed a defined protocol for completing the additional evaluation by a specialized team. It includes the completion of a twenty-two item neurobehavioral symptom inventory.

(1) When any symptom is positive, the protocol provides recommendations on physical examination, diagnostic testing, and recommendations for initial treatment interventions and referral pathways for persistent symptoms.

(2) It is possible that patients may have co-existing diagnoses, such as PTSD and TBI, and these must be appropriately evaluated. Given the expertise required to establish a diagnosis of TBI and implement appropriate treatment, the protocol must be completed by Component II Polytrauma Network Sites or Component III Polytrauma Support Clinic Teams existing within the VHA Polytrauma System of Care (see Att. A). If there is no Component II or Component III

Team at the medical center, the medical center has the option of having the evaluation completed by a specialist with appropriate background and skills, such as a neurologist, who has also had training in the evaluation protocol.

f. Between 24 and 59 percent of patients with traumatic spinal cord injury (SCI) have a concomitant TBI. The SCI system of care has the extensive multidisciplinary expertise needed to provide the required evaluation and care. Screening and evaluation are handled by the SCI team for patients followed in the SCI system of care and the initial treatment is provided by SCI Center personnel.

3. POLICY: It is VHA policy that all OEF and OIF veterans receiving medical care, within VHA, must be screened for possible TBI; those who, on the basis of the screen, might have TBI must be offered further evaluation and treatment by clinicians with expertise in the area of TBI.

4. ACTION

a. **Veterans Integrated Service Network (VISN) Chief Information Officer.** The VISN Chief Information Officer is responsible for ensuring that all medical centers install patch PXRM*2.0*8 which installs the VA TBI Screening clinical reminder and reminder dialog. This patch was made available April 2, 2007.

b. **National Director for Primary Care.** The National Director for Primary Care is responsible for ensuring that:

(1) Screen captures and training material for the current version of the VA TBI Screening reminder are posted at http://vista.med.va.gov/reminders/index.html .

(2) The reminder is kept up to date and modified, as needed, in the face of advancing clinical knowledge. ***NOTE:*** *Any updates in the reminder will be implemented using a national IT patch.*

c. **National Director for Physical Medicine and Rehabilitation.** The National Director for Physical Medicine and Rehabilitation is responsible for:

(1) Maintaining a defined protocol for evaluation of those who might have TBI, based on responses to screening. This protocol must include initial treatment interventions and must be posted at the Physical Medicine and Rehabilitation TBI website at: http://vaww1.va.gov/rehab4veterans/page.cfm?pg=20 .

(2) Providing training materials in the protocol for Component II and Component III polytrauma team members and any other specialists who will be completing the protocol.

(3) Working with each VISN Chief Medical Officer to develop clear referral protocols, identifying which Component II or III team(s), or other specialists, are to complete the secondary specialty evaluation for each VA medical center.

d. **SCI Center Chief.** Each SCI Center chiefs is responsible for ensuring that their staff has been trained in completing the evaluation protocol and for making it available at their SCI Center.

e. **Facility Director.** Each Facility Director is responsible for ensuring that:

(1) The National VHA TBI Screening clinical reminder is assigned at the "system" level, or "division" level at all divisions, in the Computerized Patient Record System (CPRS). It is to be available to all users and must be "locked" so that it is not removable by individual users.

(2) The reminder is completed for all OEF and OIF veterans who present at the facility for medical care, regardless of the clinic in which they are seen, or the reason for presentation (see Att. B for a flow chart demonstrating the process).

(3) When a veteran screens positive for possible TBI, the findings are discussed with the patient by an appropriate clinical staff member and further evaluation is offered. Consults for further evaluation must be submitted, but only after discussion with and agreement by the patient. The clinical staff member must document refusal by the patient within the progress note (using the clinical reminder dialog) if further evaluation is declined.

(4) A medical center service is clearly identified for initial management of the consults generated by positive screens. Generally this service is located at the facility; however, it is acceptable for the service to be located at another facility, such as one where the covering Component II or III polytrauma team is located.

(5) The identified service initiates contact with the referred patient within 1week, to assist in arranging the recommended evaluation. If initial contact effort is unsuccessful, follow-up efforts must include at least two telephone calls 1 week apart followed by a certified letter. These efforts and any refusals by patients to participate in the recommended evaluation must be documented in the progress notes of the patient's health record.

(6) The patient with possible TBI is offered a comprehensive evaluation by a Component II or a Component III polytrauma team. For sites that do not have a Component II or Component III team and wish to complete the evaluation protocols locally, other specialists such as neurologists can be identified to complete the evaluation protocols locally after completing training. For patients in the SCI system of care, the evaluation protocol is done by a designated SCI team.

(7) All staff at the facility involved in completing the evaluation protocol have completed the recommended training on the evaluation protocol.

5. REFERENCES: Veterans Health Initiative (VHI) teaching module, "Traumatic Brain Injury," found at http://www.va.gov/vhi/

6. FOLLOW-UP RESPONSIBILITY: The National Director for Primary Care (11PC) and Chief Consultant for Rehabilitation are responsible for the contents of this Directive. Questions should be referred to (202) 273-8558 (Primary Care) or (202) 273-8484 (Rehabilitation).

7. RECISSIONS: None. This VHA Directive expires April 30, 2012.

Michael J. Kussman, MD, MS, MACP
Acting Under Secretary for Health

DISTRIBUTION: CO: E-mailed 4/13/07
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ATTACHMENT A

**VETERANS HEALTH ADMINISTRATION (VHA)
POLYTRAUMA SYSTEM OF CARE**

1. COMPONENT I: Polytrauma Rehabilitation Centers

Four regional Polytrauma Rehabilitation Centers (PRCs) provide acute comprehensive medical and rehabilitation care for the severely injured. They maintain a full team of dedicated rehabilitation professionals and consultants from other specialties related to polytrauma. These PRCs, serving as resources for other facilities and assisting in the development of care plans, are located at Richmond, VA, Tampa FL; Minneapolis, MN; and Palo Alto, CA.

2. COMPONENT II: Polytrauma Network Sites

Twenty one Polytrauma Network Sites (PNS) provide specialized, post-acute rehabilitation services in consultation with the PRCs in a setting appropriate to the needs of veterans, service members, and families. There is one PNS in each of the twenty-one VHA Networks, including one at each of the four Component I PRC sites. Each PNS has a dedicated interdisciplinary team with specialized training, providing proactive case management for existing and emerging conditions, and identifying resources for Department of Veterans Affairs (VA) and non-VA care.

3. COMPONENT III: Polytrauma Support Clinic Teams

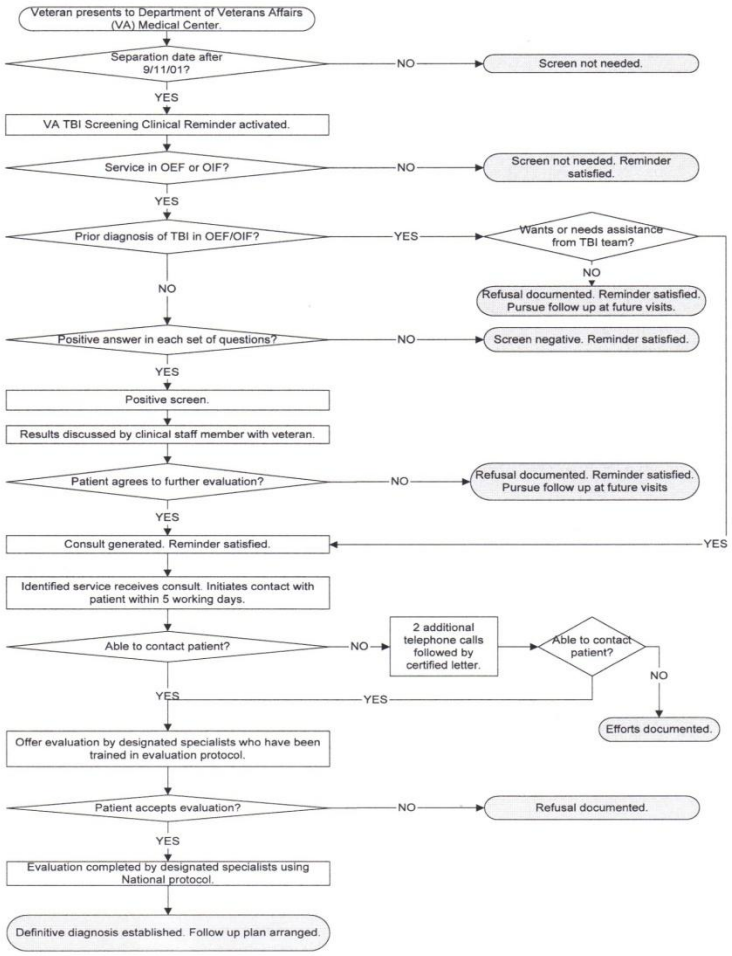
Polytrauma Support Clinic Teams (PSCT) are local teams of providers with rehabilitation expertise who deliver follow up services in consultation with regional and network specialists. They are located at many, but not all, Medical Centers that do not have a Component I or Component II center. PSCTs assist in the management of stable polytrauma sequelae through direct care, consultation, and the use of telerehabilitation technologies, as needed.

4. COMPONENT IV: Polytrauma Points of Contact

Polytrauma Point of Contacts (PPOC) are present in facilities that do not have Component I, Component II, or Component III services. Facilities that do not have the necessary services to provide specialized care must have a designated PPOC to ensure that patients are referred to a facility capable of providing the Component of services required. PPOCs commonly refer to the PNS and PSCTs within their network.

ATTACHMENT B

FLOW CHART FOR SCREENING AND EVALUATION OF POSSIBLE TRAUMATIC BRAIN INJURY (TBI) IN OPERATION ENDURING FREEDOM (OEF) AND OPERATION IRAQI FREEDOM (OIF) VETERANS



ATTACHMENT C

FREQUENTLY ASKED QUESTIONS
REGARDING TRAUMATIC BRAIN INJURY IN OPERATION ENDURING FREEDOM (OEF) AND OPERATION IRAQI FREEDOM (OIF) VETERANS

1. Do patients who are coming only for compensation and pension examinations, but are not receiving any medical care within the Veterans Health Administration (VHA), need to have the screen completed?

No. Patients who present solely for compensation and pension exams do not need to have the screen completed. These patients are not being seen in VHA for medical care, but are being seen only for a specified disability assessment at the request of Veterans Benefits Administration (VBA).

2. Do active duty military personnel who served in Operation Enduring Freedom (OEF) and Operation Iraqi Freedom (OIF) need to have the screen completed?

No. The screen is not mandated for such patients. Screening is optional. Follow-up of positive screens for this population may require referral back to their usual source of care in the military health system, depending upon the authorization received for VHA care.

3. Is screening to be done only in Primary Care or only in the "nexus clinics?"

No. Screening is required for all patients receiving medical care within VHA, not just primary care or the nexus clinics. Patients seen in Dental, Emergency Room, or Urgent Care, and any other specialty clinic; or receiving inpatient care are to have the screen performed and the reminder completed.

4. Can patients with positive screens be referred to local non-VA practitioners or clinics for further evaluation?

All evaluations for positive screens are to be done by designated specialists who have completed training in the evaluation protocol. Most commonly these are VHA Component II or Component III teams, or Spinal Cord Injury (SCI) teams. They have the multidisciplinary skills to complete the thorough evaluation required, and have been trained in the evaluation protocol. For medical centers that do not have a Component II or Component III team, it is possible to identify other staff specialists, such as neurologists, to have received, or will receive, training in the use of the evaluation protocol. Data is collected systematically on the results of the evaluations as well as the screens. ***NOTE:*** *This allows VHA to understand the breadth of the TBI problem in the OEF and OIF veterans, and allows VHA to continuously improve its services.*

5. Are only physicians and other practitioners with independent privileges allowed to complete the screens and submit referrals?

No. Other clinical staff members are allowed to perform the screens and complete the reminder. However, this staff needs to have completed the Veterans Health Initiative (VHI) Traumatic Brain Injury (TBI) module. They need to understand the basics of TBI and what the evaluation protocol involves, so that they can respond to veterans questions knowledgeably and accurately. ***NOTE:*** *Medical Centers can allow such clinical staff members to submit referral consults through approved standing orders approved by the medical staff.*

Appendix C

VAMC ASHEVILLE, NC (637)	VA RESEARCH CONSENT FORM Page 1 of 4		
Subject Name:		Date:	
Principal Investigator:	Art Horn, PhD	Subj. #:	
Title of Study:	Traumatic Brain Injury and Post-Traumatic Stress Disorder: A Comparison of Hemispheric Asymmetries in Visual Attention		

Purpose of the Study
This study is designed to contribute to research involving visual and attentional problems in mild traumatic brain injury and post-traumatic stress disorder patients who served in Iraq and Afghanistan. You have been asked to participate in this research study at the Charles George VAMC because you have mild traumatic brain injury (mTBI), post-traumatic stress disorder (PTSD), both, or neither diagnosis. There will be approximately 45 subjects total involved in this study at this hospital. Your participation in this study is voluntary. You should read the information below, and ask questions about anything you do not understand before deciding whether to participate.

Procedures
Since this is not a treatment study, all of the procedures described below will be conducted only if you agree to participate in this research study. You will be asked to complete exercises on a computer that will involve searching for visual targets and identifying certain attributes. You will also be administered a visual screen where different aspects of vision will be examined. The expected duration of the vision and attention screen will be 60 minutes.
- Vision Screen
- Attention Screen

Risks
This study has few risks, but does involve the participant's time. Every effort will be made to ensure that participants have sufficient time for the vision and attentional screening. Since some participants may have psychological conditions, there is a possibility of increased anxiety and stress. If you feel you have experienced any discomfort while participating in this study, arrangements will be made for you to see a healthcare provider.

Risks of Pregnancy or Reproductive Harm
Participating in this study does not cause any risks to pregnancy or reproductive harm

Anticipated Benefits to Subjects
There is no guarantee that you will receive any benefit from your participation in this study. However, the information obtained in this study may help doctors learn more about mild traumatic brain injury and post-traumatic stress disorder. This knowledge may be helpful to future patients.

Alternatives to Participation
The alternative is to not participate in this study.

Compensation for Participation
You will receive a complimentary non-dilated eye exam and manifest refraction for glasses. You will not be required to pay for treatment received in a VA research program.

Costs
You will not be required to pay for research-related treatment you receive as a subject in a VA research program.

Withdrawal and Termination from the Study
Your participation in the study may also be discontinued at any time without your consent by the Investigator, Institutional Review Board, the FDA or other regulatory governmental agencies, the study doctor, or the sponsor. This could happen to protect your health or safety if you experience a study-related injury, you do not follow study procedures, you do not meet study requirements, or the study is cancelled. You may withdraw from the study at any time without penalty of loss of VA or other benefits to which you are otherwise entitled. Your subsequent treatment will not be affected by your withdrawal.

Privacy and Confidentiality
Your medical records may be examined by the Sponsor of the study or the Sponsor's representatives, the Department of Health and Human Services (DHHS), the VA, other international governmental regulatory agencies and the Institutional Review Board (IRB) for verification of study related data. The results of this study may be published in the medical literature or presented at scientific medical or educational meetings, but your name or identity will not be revealed and your records will remain confidential unless disclosure of your identity is required by law. Because of the need to release information to the parties listed above, absolute confidentiality cannot be guaranteed. However, all of the data collected during this study will be used in a limited dataset that excludes 18 categories of direct identifiers for human research. Aggregate data collected from the current study may be analyzed further after completion for future projects.

New Findings
All new findings that develop during the research which may reasonably influence your desire to continue participation in this study will be provided to you as such information becomes available. If your participation is cancelled the reasons will be explained to you.

IRB APPROVAL: OCT 13 2009 **IRB EXPIRATION:** OCT 12 2010

Subject's Initials: _____

[Subject's Identification (Name - Last, First, Middle, SSN :)]

VAMC ASHEVILLE, NC (637)	VA RESEARCH CONSENT FORM Page 3 of 4		
Subject Name:		Date:	
Principal Investigator:	Art Horn, PhD	Subj. #:	
Title of Study:	Traumatic Brain Injury and Post-Traumatic Stress Disorder: A Comparison of Hemispheric Asymmetries in Visual Attention		

Emergency Care and Compensation for Injury
In the event you are injured as a result of your participation in this research study, you should return to the Asheville VA Medical Center immediately for evaluation. The VA will provide emergency care and appropriate medical treatment to you at no cost and in accordance with federal law and Department of Veterans Affairs policy. Compensation is not routinely available if injury should occur. You do not give up your option for legal recourse by signing this informed consent.

Sponsor
None

Whom to Contact
The researchers conducting this study are Art Horn, PhD and Kristen Ogden. You may ask any questions you have now. If you have medical problems or questions later, you may contact Dr. Art Horn at 828-298-7911 x 1-5242 during the day or after hours at 1-800-932-6408. If you have questions regarding your rights as a research subject, or research related injury you may contact the VAMC Asheville Institutional Review Board (IRB) at 828-298-7911, ext. 5525. To obtain answers to questions about the research, to voice concerns or complaints about the research, you may contact the investigator or research team: Dr. Art Horn at 828-298-7911 x 1-5242 during the day or after hours at 1-800-932-6408. In the event the research staff could not be reached, or in the event you wish to talk to someone other that the research staff about concerns or complaints, you may contact the Coordinator of Research and Development at the VA Medical Center Asheville at (828) 298-7911, pager 326.

Voluntary Participation Statement
I have read or have had read to me all of the above. I have been given an opportunity to ask questions and all of my questions have been answered to my satisfaction. I have been told of the risks or discomforts and possible benefits of the study. I have been told of other choices of treatment available to me.

I voluntarily consent to participate in this study. **I understand that I do not have to take part in this study, and my refusal to participate will involve no penalty or loss of VA or other benefits to which I am entitled.** I understand that I may withdraw my consent at any time and discontinue participation without penalty or loss of VA or other benefits to which I am entitled. I will receive a signed copy of this consent form. By signing this form, I willingly agree to participate in the research it describes.

IRB APPROVAL: OCT 13 2009 IRB EXPIRATION: OCT 12 2010 Subject's Initials: _____

[Subject's Identification (Name - Last, First, Middle, SSN :)]

VAMC ASHEVILLE, NC (637)	VA RESEARCH CONSENT FORM Page 4 of 4		
Subject Name:		Date:	
Principal Investigator:	Art Horn, PhD	Subj. #:	
Title of Study:	Traumatic Brain Injury and Post-Traumatic Stress Disorder: A Comparison of Hemispheric Asymmetries in Visual Attention		

Subject's Signature — Date/Time

Signature of Person Conducting the Consent Discussion — Name (print) Date/Time

Signature of Subject's Legally Authorized Representative* — Name (print) Date/Time

Signature of Witness — Name (print) Date/Time

Signature of Investigator — Name (print) Date/Time

IRB APPROVAL: OCT 13 2009 IRB EXPIRATION: OCT 12 2010

Subject's Initials: _____

[Subject's Identification (Name - Last, First, Middle, SSN :)]

ICF Version/Date:
VA FORM 10-1086 (8/2009)

Appendix D

DEPARTMENT OF VETERANS AFFAIRS
VA MEDICAL CENTER ASHEVILLE

HIPAA AUTHORIZATION FOR RELEASE OF PROTECTED HEALTH INFORMATION FOR RESEARCH PURPOSES

Study Title: Traumatic Brain Injury and Posttraumatic Stress Disorder: A Comparison of Hemispheric Asymmetries in Visual Attention.

You have been asked to be a part of a research study under the direction of **Art Horn** and his/her research team. The purpose of this study is to help differentiate between the visual and attetional symptoms related to mild traumatic brain injury and posttraumatic stress disorder.

By signing this document, you will authorize the Veterans Health Administration (VHA) to provide Art Horn and his/her research team to access the following information about you: medical diagnosis, active problems, age, mental health clinic progress notes, and Component 2 Polytrauma TBI screen.

The information that will be released also includes information regarding the following conditions:

☒ Drug Abuse
☒ Alcoholism or Alcohol
☐ Testing for or Infection with Human Immunodeficiency Virus (HIV)
☐ Sickle cell anemia
☐ None of the above

The research team may also need to disclose the information to others as part of the study process. The others may include the Asheville Institutional Review Board that will monitor this study.

If you do not sign this authorization, you will not be part of this study.
This authorization has no expiration date.

You can revoke this authorization at any time. To revoke your authorization, you must write to the Release of Information Office at the VA Medical Center Asheville or you can ask a member of the research team to give you a form to revoke the authorization. Your request will be valid when the Release of Information Office receives it.

If you revoke this authorization, you will not be able to continue to participate in the study. This will not affect your rights as a VHA patient to treatment or benefits outside the study.

IRB APPROVAL: OCT 13 2009 **IRB EXPIRATION:** OCT 12 2010

If you revoke this authorization, Art Horn and his/her research team can continue to use information about you that has been collected before receipt of the revocation. The research team will not collect information about you after you revoke the authorization.

The VHA complies with the requirements of the Health Insurance Portability and Accountability Act of 1996 and its privacy regulations and all other applicable laws that protect your privacy. We will protect your information according to these laws. Despite these protections, there is a possibility that your information could be used or disclosed in a way that it will no longer be protected. Our Notice of Privacy Practices (a separate document) provides more information on how we protect your information. If you do not have a copy of the Notice, the research team will provide one to you.

I have read this authorization form and have been given the opportunity to ask questions. If I have questions later, I understand I can contact Art Horn at 828-298-7911 X1-5242 or Kristen Ogden at x1-5620. I will be given a signed copy of this authorization form for my records. I authorize the use of my identifiable information as described in this form.

_____ _____

Signature of and **Full SSN** of Participant or Person Authorized to Sign for Participant (Attach Authority to sign, e.g. Power of Attorney)

Date

The Paperwork Reduction Act of 1995 requires us to notify you that this information collection is in accordance with the clearance requirements of section 3507 of the Act. We may not conduct or sponsor, and you are not required to respond to, a collection of information unless it displays a valid OMB number. We expect that the time expended by all individuals completing this form will average 2 minutes. This includes the time to read the instructions, gather the necessary facts and fill out the form The purpose of this form is to specifically outline the circumstances under which we may disclose data.

The execution of this form does not authorize the release of information other than that specifically described. The information requested on this form is solicited under Title 38, U.S.C. The form authorizes release of information that you may specify in accordance with the Health Insurance Portability and Accountability Act, 45 CFR Parts 160 and 164, 5 U.S.C. 552a, ad 38 U.S.C. 5701 and 7332. Your disclosure of information requested on this form is voluntary. However if the information, including Social Security Number (SSN) (the SSN will be used to locate records for release) is not furnished completely and accurately, Department of Veterans Affairs will be unable to comply with the request.

IRB APPROVAL: OCT 13 2009 **IRB EXPIRATION:** OCT 12 2010

Appendix E

Participation:

Your decision to participate in this study is voluntary and will not affect your ability to receive medical care through the VA. If you choose to participate or would like more details of this investigation please call: 1-828-298-7911, ext 1-5620.

For more information contact:

Dr. Lisa Bishop, Optometrist or
Kristen Ogden, Study Coordinator
Charles George VAMC, Asheville, NC
828-298-7911, Ext 1-5620

Department of Veterans Affairs

Vision and Attention Problems in Operation Iraqi Freedom and Operation Enduring Freedom Veterans

Our dedication to excellent medical care and research.

VAMC Asheville IRB
(828)-298-7911 x5689

APPROVED:
NOV -4 2008

Contact: 828-298-7911 Ext 1-5620

Vision and Attention Problems:

Many troops and veterans are returning from Iraq and Afghanistan suffering from problems with vision and attention. Examples of such difficulties are double vision, blurry vision, reading problems, and poor concentration. The purpose of this study is to provide further investigation on vision and attention in troops and veterans and what diagnoses and experiences may be contributing to these factors. This study will thoroughly examine multiple aspects of vision and attention that will provide beneficial information to help explain these complaints.

Details of the Study:

The VA is conducting a study to further identify what groups of OIF and OEF veterans are suffering from problems with vision and attention and what may be the underlying cause of these difficulties. The study involves a 20 minute vision screen, including a comprehensive eye exam and measuring for glasses prescription. Following the eye exam is a computerized attention test that lasts 30 minutes. The results of this study will help doctors and researchers understand the severity of problems associated with vision and attention, and what groups of personnel from OIF and OEF are most affected by these complaints.

Participation:

You may be eligible to participate in this study if:

- You are between the ages of 18-39
- Have returned from service from Operation Iraqi Freedom or Operation Enduring Freedom
- You are experiencing problems with vision or attention.
- Even if you are not experiencing problems, you may still be eligible to participate in this study.