An Electrophysiological Investigation of Attentional Bias and Divided Attention in a Forensic PTSD Population

by

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Abstract

A body of evidence relying on probe detection tasks has suggested that high anxious individuals may exhibit biased (enhanced) selective attention to threat stimuli. Research has demonstrated that both redirection of attentional focus and working memory load can reduce fear response, suggesting that cognitive processes may interfere with or diminish emotional processing. This study utilized event-related potential (ERPs) and behavioural probes to examine the effects of cognitive load on attentional bias towards ecologically threatening stimuli in 20 posttraumatic stress disorder (PTSD) patients and 20 healthy controls (HC) during three dot-probe task conditions: a) attending to visual threat stimuli while ignoring the auditory distraction (DPV); b) attending to auditory stimuli while ignoring the visual threat stimuli (DPA); and c) attending to both visual and auditory stimuli (DPD). Both groups showed early attentional bias to threat faces as indexed by P100 and face-specific N170 visual ERP components and in response to the dot probe-task. Attentional bias appeared as vigilance effects in the HC group while in patients bias was seen with vigilance, avoidance, and disengagement processing, as indexed by percentage incorrect response, reaction time and P300 amplitude/latency measure to probes replacing threat stimuli. Predominately evidenced in the PTSD group, DPA and DPD acted to diminish, augment and modify attentional bias styles. The results provide electrophysiological and behavioural support for early and late attentional biases in PTSD and possible moderating effects of perceptual and cognitive load.

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1. Introduction

1.1 Posttraumatic Stress Disorder

Posttraumatic Stress Disorder (PTSD), an anxiety disorder that develops in response to a traumatic experience, is characterized by the core features of re-experiencing (i.e., re-experiencing threat related event[s]), avoidance behaviours (i.e., avoidance of stimuli including thoughts that could serve as reminders for the event), numbing of responsivity, and hyperarousal. PTSD is unique among psychiatric disorders in that its symptoms are tied directly to an etiological event; the traumatic stressor (Bresau, 2002). The Diagnostic and Statistical Manual of Mental Disorders – IV (DSM-IV) defines the traumatic stressor to be the "experiencing, witnessing, or confronting of an event or events that involve threatened or assurance of death or serious injury, or a threatening of physical integrity of oneself or others" (APA, 2000).

PTSD is characterized by a collection of symptoms that reflect a prolonged adverse response to an extremely distressing event. Current diagnostic criteria for PTSD (DSM-IV, American Psychiatric Association, 2000) require that there be an identifiable stressor that produced intense fear, helplessness, or horror (Criteria A); the event be persistently reexperienced (Criteria B); stimuli associated with the traumatic event be avoided and/or there is numbing of responsiveness (Criteria C); and there be evidence of persistent arousal (Criteria D). Also, the disturbance must have a duration greater than one month (Criteria E) and cause significant distress or impairment (Criteria F).

1.1.1 Prevalence.

Using data from the National Comorbidity Survey (NCS) on a large nationally representative sample of men and women, Kessler and colleagues (1995) reported that 60% of men and 50% of women have experienced a traumatic event at some point in their lives, with the majority experiencing two or more traumatic events. Among traumatized individuals, the lifetime prevalence of PTSD as reported in the NCS is 8% for men and 20% for women. The likelihood of developing PTSD varies with the type of trauma experienced, situational and personal characteristics, and the severity of trauma. Trauma severity refers to features such as the duration of a trauma, the number of occurrences, and the extent of injury.

1.1.2 Course.

On average, posttraumatic symptoms decrease over time, but the course of PTSD varies both within and between individuals. The DSM-IV includes several specifics for providing information about the course of PTSD. An acute case is one in which the duration of symptoms is less than 3 months, where as a chronic case is one in which symptoms last 3 months or longer. Delayed onset of PTSD is diagnosed when at least 6 months have elapsed between traumatic exposure and the onset of symptoms. Most cases of PTSD are not acute, as defined in DSM-IV. More than one-third of cases never recover. The median time to remission (the time by which 50% of cases recovered) is 36 months among individuals who received treatment and 64 months among individuals who did not. Individuals who are asymptomatic at one time may find that stressors, both related and unrelated to the initial trauma, reactivate their symptoms.

Onset of PTSD typically occurs immediately following the traumatic event (Shalev, 2000). Although a subset of individuals diagnosed with PTSD recover within a few months, many go on to develop chronic PTSD, lasting 3 months or longer. Approximately 82% of PTSD cases meet criteria for chronicity, with approximately 74% lasting 6 months or more (Breslau, 2001b). In the NCS, roughly 90% of participants retrospectively reported that PTSD symptoms persisted at 3 months, and more than 70% still experienced symptoms 1 year after the traumatic event (Kessler et al., 1995). Unfortunately, PTSD can last for decades or even lifetimes (Yule, 2001).

1.1.3 Comorbidity.

Chronic PTSD is often accompanied by other Axis I psychiatric disorders and general impairment of psychosocial function. In the NCS, Kessler and colleagues (1995) reported that 88% of men and 79% of women with lifetime PTSD had at least one comorbid diagnosis. Major depression was the most common comorbid diagnosis, occurring in just under half of the men and women. PTSD was associated with higher prevalence of all the disorders studied: major depression, dysthymia, mania, generalized anxiety disorder, panic disorder, simple phobia, social phobia, agoraphobia, alcohol abuse/dependence, drug abuse/dependence, and conduct disorder. Although a history of psychiatric disorder is a risk factor for developing PTSD following a traumatic event, PTSD often leads to the development of psychiatric disorder as well. In the NCS, PTSD was primary for the majority of cases in the development of affective and substance-use disorders, and also in the development of conduct disorder among women.

1.2 Cognitive Abnormalities in PTSD

PTSD is also characterized by the allocation of attentional resources towards the recognition of threatening stimuli (Harvey, Bryant, & Rapee, 1996), problems with concentration, and deficits in memory function (Uddo, Vasterling, Brailey, & Sutker, 1993). Given the problems associated with memory processes and attention seen in traumatized populations, it is not surprising that information-processing theories have been proposed to explain the syndrome known as PTSD (e.g., Brewin, Dalgleish, & Joseph, 1996; Foa, Steketee, & Rothbaum, 1989).

Individuals with PTSD experience cognitive alterations ranging from impairments in overall memory functioning to difficulties specific to trauma-related cues, which are related to the development and/or maintenance of the disorder (Moore, 2009). The effects of PTSD on cognitive capacities have been studied extensively. For example, PTSD has been associated with: a) general and diverse cognitive impairment (war veterans; Barrett et al., 1996); b) delayed free recall (rape victims; Jenkins et al., 1998); c) compromised memory performance (traumatized nonveterans; Moradi et al., 1999); d) impaired sustained attention, mental manipulation, and initial acquisition of information (war veterans; Vasterling et al., 1998); e) increased attention to mild threat stimuli (traumatized nonveterans; Bryant &d Harvey, 1997); f) attentional biases associated with the speed, accuracy, and depth of information processing (reviewed in Wolfe & Schlesinger, 1997); g) impaired retroactive inference (war veterans; Vasterling et al., 1998; Yehuda et al., 1995; cf. McNally, 1997); and h) difficulties in retrieving specific autobiographical memories in response to positive trait cue words (war veterans; McNally et al., 1995). For the purpose of this paper, further discussion will be focused on information processing bias, specifically attentional bias (i.e., selective bias) toward threatening stimuli. The following section briefly describes the theoretical models set forth regarding anxiety and cognition.

1.3 Biased Processing Theories of Anxiety

Cognitive theories have suggested that anxiety disorders may be associated with a distorted perception of information related to danger. Empirical evidence has shown that anxiety is associated with a systematic bias in the cognitive system. Anxious individuals show a pattern of selective processing that operates to favor the encoding of threatening information (Dalgleish & Watts, 1990; Eysenck, 1992; Logan & Goetsch, 1993; MacLeod, 1990). This selective processing to threatening information has been found in PTSD patients (McNally, Kaspi, Riemann, & Zeitlin, 1990).

Eysenck (1992), Williams et al. (1988, 1997), and Mogg and Bradley (1998) have theorized about the relationship between anxiety and threat-related attentional bias. The three individual theories suggest a link between attentional bias and anxiety, although the nature of this relationship differs in each model. Williams et al.'s model proposes that high trait anxiety imposes a consistent influence on individual's reaction to environmental stimuli, so that anxious individuals selectively attend to threat-related stimuli and non-anxious individuals selectively attend away from threat-related stimuli. Additionally, two distinct pre-attentive processing stages are postulated (see Figure 1). At the first stage, the threat value is computed by affective decision mechanism (ADM), with anxious individuals increasing the resulting threat value output. If threat value is determined to be high enough, a secondary resource allocation mechanism (RAM) is

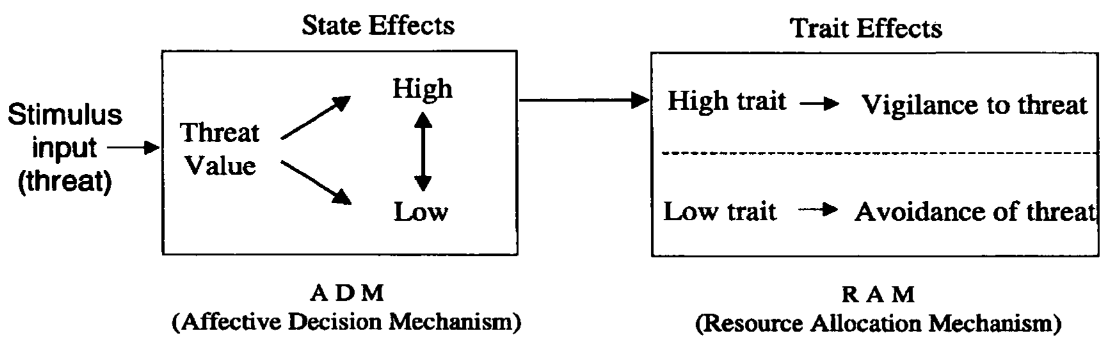


Figure 1. The effects of state and trait anxiety according to the Williams et al. (1988, 1997) model of attentional bias

triggered, which leads to the allocation of attentional resources toward the stimulus. High levels of trait anxiety lead to the allocation of attentional resources towards the stimulus and in contrast, low trait levels lead to attention being directed away from the threatening event. In contrast, Mogg and Bradley's (1998) model suggests that all individuals selectively attend to stimuli perceived as dangerous. The differences in the attentional responses to threat of anxious and non-anxious individuals are primarily due to their subjective appraisal of environmental stimuli. That is, the threshold for perceiving a stimulus as dangerous is lower in anxious individuals than in non-anxious individuals. Finally, Esyenck's theory argues that hypervigilance is an essential feature of trait anxiety and that focused attention to threat-related information is one component of this hypervigilance. According to Esyenck, high trait anxious individuals display a great vigilance toward threat-related stimuli at all levels of cognition, including attention, memory, and interpretation of stimuli. He further proposed that attentional bias involves several components, including (a) greater visual scanning of the environment for threat, (b) greater distractibility by environmental stimuli whether threat-related or not, and (c) that these components interact to attend to threat-related stimuli in the environment.

These models do not allow evaluation of the components of attentional bias and stages of processing. These models predict the component of vigilance/facilitated attention towards threat. Difficulty disengaging from threat and attentional avoidance of threat components are not represented. A brief explanation of the components of attentional bias and stages of processing is provided below. Despite the differences between the above models, the theories agree on the proposal that threat-related attentional bias is directly related to anxiety and that this bias may contribute to the onset and/or maintenance of anxiety disorders. Research testing these theories has supported an association between anxiety and threat-related attentional bias. Studies have generally found that anxious and high trait anxious individuals selectively attend to threat-related words or pictures, whereas non-anxious individuals do not (e.g. Asmundson & Stein, 1994; MacLeod et al., 1986; Mathews & MacLeod, 1985; Mattia et al., 1993).

1.4 Attentional Bias

Research suggests that threat-related attentional bias is content-specific (Asmundson & Stein, 1994; Hope et al., 1990), where individuals with an anxiety disorder selectively attend to information related to their disorder or fear, but not to information related to other disorders or fears. Additionally, several studies have found that anxious individuals with a comorbid depressive disorder do not display an attentional bias toward threat-related stimuli (Musa et al., 2003; Rink & Becker, 2005). Mogg and Bradley (1998) argue that the decreased motivation associated with depression suppresses the behavioural component of focusing attention on threat-related stimuli. However, these findings are not unequivocal, as others have reported that depressed individuals do selectively attend to threat related stimuli (Mathews et al., 1996).

1.5 Attentional Bias and Anxiety

Both trait anxiety and state anxiety have been associated with threat-related attentional bias. Whereas several studies have found that state anxiety was only associated with threat-related attentional bias in high trait anxious individuals (Broadbent & Broadbent, 1988; Egloff & Hock, 2003; MacLeod & Mathews, 1988), a study by

Rutherford, MacLeod, and Campbell (2004) reported that high trait anxious individuals only displayed a threat-related attentional bias when state anxiety was elevated. These findings suggest that elevations in both trait and state anxiety may be associated with attentional bias, although the specific extent of this is unclear.

Following Posner and colleague's (1988) suggestion that disengagement from visual stimuli serves a basic role in selective attention (Posner & Petersen, 1990), researchers have examined the components of attentional bias. Derryberry and Reed (2002) argued that threat-related attentional bias consists of both automatic and voluntary attentional processes and discovered that the ability to disengage attention from threat-related information is important in restricting this bias. Studies have reported that the attention bias displayed in anxious individuals may be due to an impaired disengagement from threat-related stimuli, as apposed to an initial orientation toward such stimuli (Amir et al., 2003; Derryberry & Reed, 2002; Fox et al., 2002; Koster et al., 2004; Yiend & Mathews, 2001).

The literature strongly indicates that anxious individuals display an attentional bias to threat-related information that is not displayed in non-anxious individuals. Studies have reported such findings with PTSD patients, as it is also characterized by the allocation of attentional resources towards the recognition of threatening stimuli (Harvey, Bryant, & Rapee, 1996). Psychophysiological studies in PTSD patients have reported heightened responses (e.g. heart rate, blood pressure, skin conductance, and facial electromyograms) to stimuli which are related to the traumatic event (Buckely & Kaloupek, 2001; Orr, Metzger, & Pitman, 2002; Orr & Roth, 2000), where acoustic combat noises, word stimuli, and relevant scripts have been presented to war veterans and civilians with PTSD (Blanchard, Kolb, Taylor, & Wittrock, 1989; McNally & Lorenz, 1987; Orr, Pitman, Lasko, & Herz, 1993).

1.6 Measures of Attentional Bias

Several objective task paradigms of information processing have been developed, such as the Stroop colour-naming task (Stroop, 1935) and the dot probe task (MacLeod, Mathews, & Tata, 1986). The Stroop task involves the presentation of names of colours written in ink colour that differs from the colour names. The participants are asked to name the ink colour of the word as quickly as possible while ignoring the word itself. A modified version of this classic paradigm is the emotional Stroop task, which includes emotionally relevant words (i.e., threatening words). In this task the participants are shown words of different emotional valence and asked to name the color in which they are printed while ignoring their meaning. Differences in colour-naming latencies represent the degree to which word meaning is selectively processed, where naming the colour of threat-related words will have longer latencies compared to the neutral words (MacLeod, 1991). There have been numerous studies showing that clinically anxious individuals exhibit a selective attentional bias toward threatening material, including generalized anxiety disorder patients (e.g., Bradely, Mogg, White, Groom, & de Bono, 1999) and specific and social phobics (e.g., Mattia, Heimberg, & Hope, 1993; Thorpe & Salkovskis, 1997; van den Hout, Tenney, Huygens, & De Jong, 1997). Studies have also shown slower reaction times with PTSD patients during the modified Stroop task, when they are exposed with trauma-relevant material (Bryant & Harvey, 1995; Foa, Feske, Murdock, Kozak, & McCarthy, 1991; Kaspi, McNally, & Amir, 1995). However, there is considerable doubt whether the modified Stroop test constitutes a measure of attentional bias to threat because a similar degree of interferences was found in relation to positive words (e.g., McNally, Riemann, Louro, Lukach, & Kim, 1992). De Ruiter and Brosschot (1994) suggested cognitive avoidance as an alternative explanation for the Stroop results. Additionally, it has also been proposed that response interference on the Stroop task may occur as a result of emotional arousal associated with the threatening stimuli (MacLeod, Mathews, & Tata, 1986).

Researchers have argued that a more accurate, and straightforward measure of attentional bias involves the allocation of visual attention in discrete areas of one's visual field (Bryant & Harvey, 1997; MacLeod et al., 1986), as observed in the dot probe task (MacLeod, Mathews, & Tata, 1986; Mogg, Bradley, & Williams, 1995). The dot probe task was adapted from paradigms in experimental cognitive psychology that indicated spatial attention can be assessed from the speed of manual responses to visual probes (Posner, Snyder, & Davidson, 1980; Navon & Margalit, 1983). That is, individuals are faster to respond to a probe stimulus that is presented in an attended, rather than unatteneded, region of a visual display. For example, in this task, two stimuli are presented simultaneously on a screen (e.g., a threat stimulus and a neutral stimulus), and immediately after they disappear, a dot probe is presented in the position of one of the stimuli. The threat scenes and probes appear randomly either on the left or right side of the screen, providing three within-subject variables: threat value, threat location, and probe location. Participants are required to respond as quickly as possible to the probe. Based on the attentional bias theory, there should be faster reaction times for probes that occur in the same location as high threat (relative to non-threat) scenes, compared with mild threat (relative to threat) scenes. Decreased reaction times to probes replacing threat related relative to neutral cues suggest increased allocation of visual attention towards threat-related cues (MacLeod et al., 1986; Fox et al., 2006). Consistent with this prediction, subjects with generalized anxiety disorder (MacLeod et al., 1986) and high trait anxiety (MacLeod & Mathews, 1988) respond faster when anxiety-laden words are presented near the target than when they are distant from the target. The dot probe experimental methodology has two advantages over self-report questionnaire measures and other cognitive methodologies. First, any methodology that uses self-report can only capture those aspects of cognition that can be verbalized. Such data can only provide partial support for a cognitive model of the emotional disorders. Second, the dot probe task provides an opportunity for the direct assessment of visual attention over and above any response bias because it requires a neutral response (button press) to a neutral stimulus (dot probe). It is proposed that whereas slower response on the Stroop task may be associated with emotional arousal, faster responses on the dot-probe task accurately reflect a bias in visual attention to threat stimuli (Bryant & Harvey, 1997). It is for this reason that the present study employed the dot probe task.

1.7 Components of Attentional Bias

Attentional bias towards threat may be characterized by (1) facilitated attention to threat (also known as vigilance), (2) difficulty disengaging attention away from threat, or (3) attentional avoidance of threat (Cisler et al., 2009).

1.7.1 Facilitated Attention to Threat

Facilitated attention refers to the relative ease or speed of orienting to threat stimulus and can be demonstrated by a quicker response to a target when a threat cue is subsequently presented in the same location. Individuals with high levels of self-reported anxiety have been shown to allocate their visual attention towards the location of threat in the dot-probe task (Fox, 2002).

1.7.2 Delayed Disengagement from Threat

Difficulty disengaging away from threat refers to inability to rapidly disengage from the threat stimuli (Georgiou et al., 2005). In other words, it refers to the degree to which attention has been captured by a threat stimulus and thus impairs switching attention from the threat to another stimulus. The dot probe task has been used to investigate the effects of disengagement and some evidence suggests that anxious individuals demonstrate difficulty in disengagement (Koster et al., 2004). When a threat cue is presented and a target subsequently presented in another location, high state-anxious individuals have been observed to take longer to detect the target relative to when either a positive or a neutral cue is presented (Fox et al., 2001).

1.7.3 Attentional Avoidance

Attentional avoidance occurs when attention is preferentially allocated toward locations opposite the location of the threat cue. High trait anxious individuals have demonstrated attentional avoidance of threat cues (Koster et al., 2006). However, several studies have not consistently observed the same effects (Bradley, Mogg, Falla, & Hamilton, 1998).

1.8 Stages of Information Processing

Attentional bias has been observed at varying stimulus duration presentations (Bar-Haim et al. 2007; Mogg et al., 1993), suggesting that the nature of attentional bias may be dependent on the stages of information processing. The two stages of information processing are automatic and strategic processing (Shiffrin & Schneider, 1977; 1984). Processing that is effortless, capacity free, unintentional, and outside of conscious control is referred to as automatic processing, whereas strategic processing refers to processing that is capacity-limited, effortful, intentional and dependent on conscious control (Shiffrin & Schneider, 1977). Automatic and strategic processing is theoretically relevant in psychopathology because it relates to limited control over the processing biases (McNally, 1995).

Studies using masked stimuli presented briefly (e.g., 17 ms) have demonstrated that attentional bias can occur under conditions of limited conscious awareness of the presence of threat (Moog, Bradley, & Williams, 1995). Studies have also observed attentional bias towards supraliminal stimuli using the dot probe task (Koster, Crombez, Verscheure, and De Houwer, 2006), Stroop task and visual search tasks (Bar-Haim et al., 2007).

1.9 Threat Related Stimuli

A limitation of previous studies is the use of word stimuli in emotional Stroop and dot probe research. Based on an evolutionary perspective, word stimuli do not explain oriented action readiness in threatening situations (e.g., Mathews & MacLeod, 1994). The use of word stimuli has been questioned due to the necessity of rapid detection and attentional allocation to threatening material (McNally, 1995). Additionally, the use of threat words acts as a confound, as these words may be more frequently used by high anxious individuals (Bradley et al., 1997).

Previous research using specific traumatic stimuli has generally shown that anxious participants exhibit an attentional bias toward threat-related stimuli however the nature of this bias is not well understood. It is not clear whether the increased attentional bias observed in anxious individuals is tied to threat-related stimuli, to negatively valenced emotional stimuli, or to emotional stimuli in general. Several cognitive emotion researchers have resorted to the use of ecologically valid stimuli, such as emotional facial expressions as threat-related stimuli. Some studies have reported findings that are consistent with a bias towards both negative and positive faces relative to neutral faces (e.g., Bradley, Mogg, White, Groom, & de Bono, 1999). Others (e.g., Bradley, Mogg, Falla, & Hamilton, 1998; Mogg & Bradley, 1999) have reported an attentional bias only to angry faces and not to happy faces.

Suggestions have been made that subcortical projections leading to the amygdala allow for the rapid evaluation of the threatening stimuli and, based on that evaluation, attention may be allocated preferentially to such stimuli (Ledoux, 2000). Additionally, number of studies have demonstrated an important role of the amygdala in detecting emotionally salient events and in mediating responses to these stimuli. Emotional stimuli, particularly fearful facial expressions, activate the amygdala and other connected limbic structures (Liu, Ioannides, & Streit, 1999; Morris et al., 1996). Given this, research has suggested that affective facial expressions (angry and happy) may be processed automatically (Vuilleumier & Schwartz, 2001). This threat bias has been measured in terms of interference in the top-down cognitive control of attention (Fenske & Eastwood, 2003; Simpson et al., 2000; William, Mathews & MacLeod, 1996). For this reason, the threat bias is detectable in multiple domains of attention. Studies have shown that when there is conflict and competition for attention, emotional processing is prioritized over cognitive processing, suggesting that threat-related attention interference effects can be attributed to changes in emotional processing (Easterbrook, 1959; Leith & Baumeister, 1996; Meinhardt & Pekrun, 2003; Wood, Mathews, & Dalgleish, 2001). It may be for this reason that anxious compared to nonanxious individuals may be susceptible to disruptions in attention by threat because they devote more emotional processing resources to threat-related information (Mathews & MacLeod, 2002; Mogg, Millar, & Bradley, 2000). Recent research suggests that threat-related distracters reduce the degree to which anxious individuals effectively recruit cognitive control resources to support task-focused processing (Bishop, Duncan, Brett, & Lawrence, 2004; Compton, 2003; Compton et al., 2007). For example, a neuroimaging study by Bishop et al. (2004) showed reduced activity of neural regions associated with cognitive control (i.e., anterior cingulate cortex and lateral prefrontal cortex) when individuals with heightened anxiety viewed threat-related emotional distracters (fearful faces).

Research has demonstrated deactivation or suppression of the amygdala in tasks that involve higher-order cognitive processing (Drevets & Raichle, 1998). Research also suggests that amygdala-mediated emotional processes may be regulated by higher-order processing such as effortful evaluation and appraisal (Hariri, Mattay, Tessitore, Fera, & Weinberger, 2003) and may be eliminated when attention is directed to another task (Pessao et al., 2002). Pessoa et al. (2002) found that a shift in attentional focus effectively reduces differential amygdala activation to emotional stimuli. Furthermore, research has demonstrated that amygdala activation varies as a function of cognitive load (Pessao et al., 2009). Dvorak-Bertsch et al. (2007) has demonstrated that both redirection of attentional focus and working memory load can reduce fear response (measured with fear potentiated startle). It has been suggested that processing emotional stimuli, like neutral stimuli, requires the availability of attentional resources (Pessao et al., 2002; Pessao, Padmala, & Morland, 2005). These studies suggest that although cognitive processes may interfere with or diminish emotion processing, the necessary and sufficient conditions for observing such effects are unclear. These cognitive interference effects may in part be explained with the concept of attentional capacity theory.

1.10 Multiple Resource Theory

This interference effect of cognitive processes can be explained in terms of the concept of attentional capacity theory which proposes that the human capacity for processing information may be conceived of as drawing on a finite amount of attentional resources that can be shared during the concurrent performance of two or more tasks. Improvement of performance on one task therefore comes at the expense of performance on other tasks (Kahneman, 1973; Navon & Gopher, 1979; Norman & Bobrow, 1975). Kahneman's (1973) limited capacity describes attention as a limited resource that can be thought of as the amount of mental effort or energy required to perform a task. This model encompasses arousal, mental effort, and allocation of attention to explain attentional resource capacity. This single resource model's most serious problem is that it does not adequately explain the strong influence of similarity in dual task studies. The model proposes that we have a limited capacity which is allocated by a single central processor. This implies that any two tasks will interfere with each other if the capacity needed for them exceeds the available capacity. However, a number of studies suggest it is not the difficulty but the degree of similarity of the two tasks that is the most important factor in dual task performance (Wickens et al., 1983).

Multiple resource models have replaced single resource models like Kahneman's because they better account for many dual task performance phenomena. Navon and Gopher (1979) argued that individuals have a multiple channel processor (multiple structures), that each processor may have its own capacities, and that each capacity may be shared by several processes. The most detailed of multiple resource models was proposed by Wickens and colleagues (1980, 1984). It contains three dichotomous dimensions (stage of information processing, modalities of processing and codes of processing) that represent the processing resource, as illustrated in Figure 2. The 'stages of processing' dimension indicates that perceptual/central and cognitive/response tasks use different resources from those underlying the selection and execution of action (Isreal, Chesney, Wickens, & Donchin, 1980). The modalities of processing (input: visual and auditory, output: speech and manual) dimension indicates that auditory

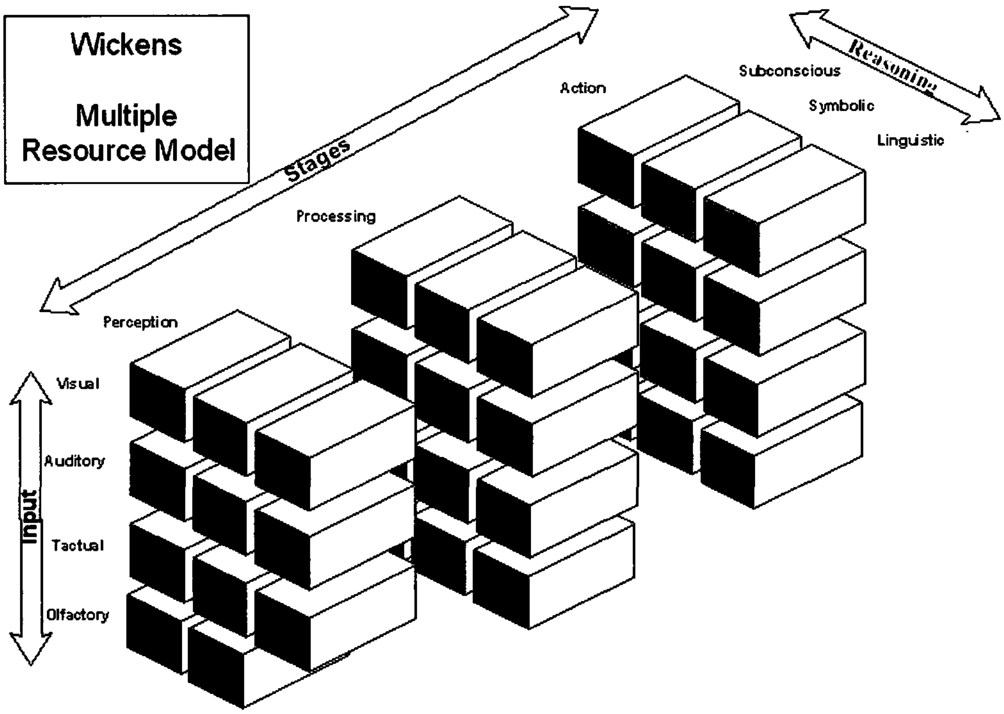


Figure 2. Wickens' (1984) multiple resource theory model.

perception uses different resources than does visual perception. The 'codes of processing' (verbal and spatial) dimension indicates that spatial activity uses different resources than those required for verbal/linguistic activity. This model proposes that time sharing will be better when two tasks use different levels along each of the three dimensions. However, this does not imply that perfect time-sharing will emerge whenever different resources are used for two tasks because the two tasks will still compete for common perceptual resources. Mental workload is a concept related to multiple resource theory that overlaps but is distinct. The multiple resource model consists of three components related to demand, resource overlap, and allocation policy.

Mental workload relates to demand imposed by task on the limited mental resources, whether considered as single or multiple (Moray, 1979). Based on this concept of limited processing capacity (Kahneman, 1973; Navon & Gopher, 1979; Wickens, 1984), cognitive resources are limited and a supply and demand problem occurs when the individual performs two or more tasks that require a single resource. Excess workload caused by a task using the same resource can cause decrements and result in error or slower task performance.

A direct approach to investigating the allocation of central resources involves the use of a dual-task paradigm of workload assessment, in which event-related potentials (ERPs) and performance measures of a secondary task are used to monitor the resource shifting/sharing in an ongoing primary task (Donchin, Kramer, & Wickens, 1986). In dual task paradigms probed with ERPs, the frequently used auditory oddball paradigm requires the participants to listen to a randomized series of low and high probability tones, being instructed to ignore the frequent (or 'standard') tone and to respond to the rare (i.e., 'deviant') or target tone via key press. These target stimuli elicits a so-called P300 component in contrast to the non-target stimuli.

1.11 Event-Related Potentials and Attention

Behavioural measures provide an indirect measure of attentional processing (Horley et al., 2004) and can be confounded by post-perceptual processing (e.g., decision making, motor responses) (Handy et al., 2001). Event-related potentials (ERPs) are stimulus/event-locked electrical potentials extracted from the scalp-recorded electroencephalogram (EEG) by filtering and averaging (Picton et al., 2000). The stimulus-locked ERPs are noninvasive, sensitive measures of brain functional changes, which allow monitoring of cognitive activity on a millisecond-by-millisecond basis, are superior to other neuroimaging techniques in tracking mental processing (Picton et al., 2000). In addition, ERP recordings can be time-locked both to attended and non-attended events not requiring a behavioural response, thus revealing information processing that stimuli undergo in and outside the focus of attention (Picton et al., 2000).

The main advantages of studying human cognition with ERPs are (a) its ability to provide a continuous measure of cerebral information processing even in the absence of an overt motor response; (b) its suitability for exploring the neural substrates of different attention mechanisms across different task conditions; (c) its temporal resolution that allows monitoring of successive stages of cognitive processing; and (d) its low costs and noninvasiveness.

Scalp-recorded ERPs are broadly divided into exogenous and endogenous components. Exogenous components, which occur relatively early (<100 ms) after stimulus onset, are obligatory responses. The amplitudes and latencies of exogenous components are determined by the physical properties of the external eliciting event and are considered to be insensitive to psychological manipulations (Picton et al., 2000). The later (100 ms -1000 ms) endogenous ERP components are manifestations of information processing (Picton et al., 2000), which reflect the interaction between the significance of the stimulus and the manner in which the participant processes the stimulus (Fabiani et al., 2000).

The P300 amplitude, illustrated in Figure 3, can be affected by the amount of attention that is applied to a certain stimulus and is viewed as a measure of processing in a limited capacity system (Kok, 2001). The P300, an endogenous positive ERP, occurs in response to a stimulus to which the subject is actively attending and is particularly pronounced if the stimulus is infrequent or unexpected (Sutton et al., 1965). The latency of the P300 is an index of stimulus classification speed and is independent of response selection and thus of response time (Polich, 1998). Its latency increases when targets are harder to discriminate from standards. Two subcomponents are typically identified, the P300b and the P300a. The former is a late positive voltage deflection located 250-500 ms post stimulus onset, with a centroparietal maximum in response to target detection, while the P300a has a frontal-central maximum and is elicited involuntarily by rare novel stimuli (e.g. 'dog bark', 'train whistle') that do not require a behavioural response (Picton et al., 2000). For the purpose of this paper, P300 will be used to indicate the P300b, which is elicited only under conditions involving voluntary target detection. Literature has indicated that the P300 amplitude indexes a limited central capacity system that depends on processes that serve to identify a target stimulus and these processes have

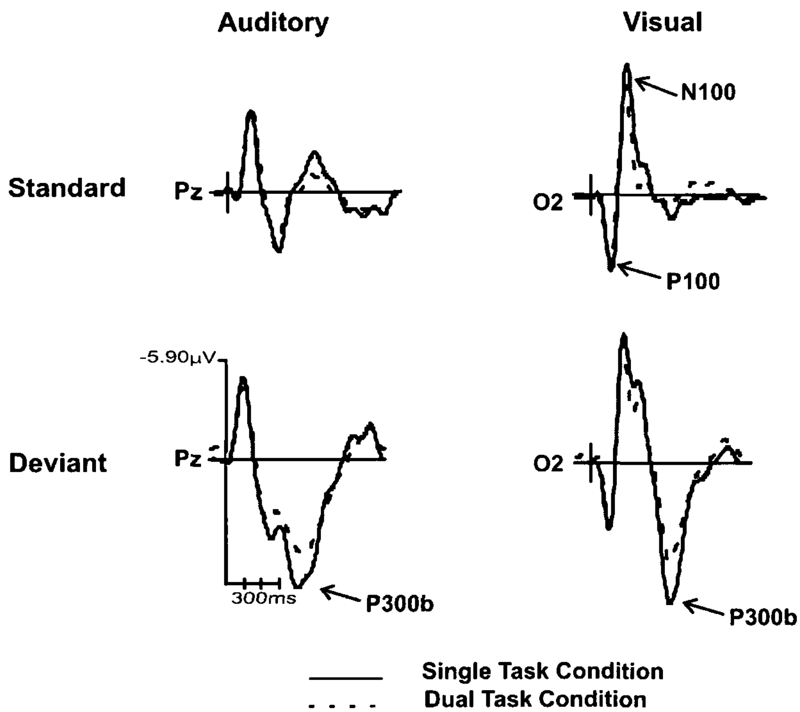


Figure 3. Example of grand averaged P100, N100 and P300b component during auditory and visual single and dual task conditions.

been referred to as 'perceptual-central' or 'response set' processes (Kok, 1997). Figure 4 illustrates the relationship between various resources processing stages and ERP components. It is assumed that the amplitudes of the specific ERP components reflect the activation of processing stages by specific resource mechanisms. Of most interest to the present paper is the P300 elicited by the activation of the perceptual-central resources. Evidence suggests that the P300 component is a reliable index of processing resources under dual-task conditions. A number of studies incorporating dual-task paradigms have reported that the P300 component appears to be reciprocally distributed across the two tasks such that perceptual (but not response) manipulations that produce larger P300s in one task produce smaller P300s in the other (Israel et al., 1980; Wickens et al., 1983; Strayer & Kramer, 1990). Nash and Fernandez (1996) demonstrated that the P300 could serve as an index of the distributing of attentional resources. They examined whether the timing of stimulus presentation would affect P300 amplitude. An auditory primary task was presented together with a visual stimulus secondary task, separated by an interval of 400 ms. Participants were either placed in an "attended" condition where they were required to count the presentation of deviant and standard tones, or they were placed in an "unattend" condition where the auditory tones were to be ignored. The attend condition produced a larger P300 amplitude for the auditory task, and a subsequent reduction in P300 amplitude for the secondary task. These results provided evidence that the P300 is an index of neural activity associated with the reallocation of limited processing resources and the processing of specific stimulus information.

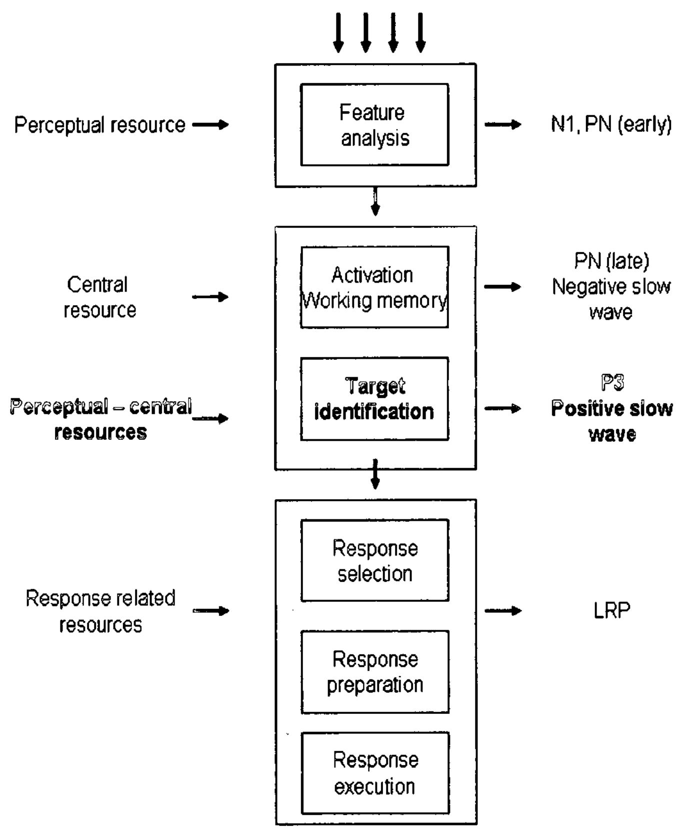


Figure 4. Illustration of the relationship between various resources processing stages and ERP components (Kok, 1997).

1.12 Facial Processing in Anxiety

Fearful faces have been used in multiple studies of the threat bias because they are salient and socially significant (Mathews & MacLeod, 2002). Bryne and Eysenck (1995) found relatively more attention for angry faces in high compared to low trait anxious individuals, and low trait anxious individuals to be slow in detecting angry faces among happy faces. Using the dot probe task, Bradley et al. 1997 found an attentional bias away from angry faces (compared to neutral faces) in individuals with low levels of anxiety. Additionally, several studies have demonstrated that individuals who report high levels of trait anxiety are faster to detect probes occurring (during the dot probe task) in a location previously occupied by an angry facial expression, relative to a neutral or happy facial expression (Bradley, Mogg, Falla, & Hamilton, 1998; Mogg & Bradley, 1999), suggesting an anxiety-related bias to allocate attentional resources toward the location of angry faces (Mogg & Bradley, 1999). Specifically, this bias was only observed when angry faces appeared in the left visual field and when the faces were backward masked (Mogg & Bradley, 1999), suggesting that there may be a hemispheric bias for processing angry facial expressions.

1.13 Neuroimaging Correlates of Emotive Facial Processing

Neuroimaging studies have been employed to characterize brain activity associated with viewing faces. Activation of the fusiform gyrus (FFG) has been generally associated with face processing, which is commonly referred to as the 'face processing region', and activation is greater in the right versus the left hemisphere (Haxby et al., 2000; Esslen et al., 2004). With their high temporal and spatial resolution, magnetoencephalographic (MEG) studies have found that the FFG may selectively encode faces at ~165 ms post face presentation and convert the sensory input for further processing (Halgren et al., 2000). The superior temporal gyrus has been associated with changing features of a face, such as facial expressions (Fox et al., 2009; Winston et al., 2003). Greater activation in the ventral occipitotemporal cortex and the primary and secondary visual areas has also been observed during processing faces with emotional expressions (Pessoa et al., 2002). Central regions involved in facial affective processing includes the prefrontal cortex (PFC), specifically the anterior cingulate cortex (ACC) and to a lesser extent the posterior cingulate cortex (PCC) (Blair et al., 1999; Esslen et al., 2004). Although facial processing is typically associated with increased activity in the right hemisphere, emotive expressions tend to enhance activation in the left hemisphere, but the R>L activation asymmetry is still evident.

Sub-cortical structures (i.e., the basal ganglia and the amygdala) are also associated with facial emotive processing. The basal ganglia appear to play a dominant role in processing positive facial expressions (Adolphs, 2002; Fu et al., 2007) whereas the amygdala is involved in processing fear and anger (Whalen et al., 1998; Morris et al., 1998). Other structures that are also implicated in processing facial expressions are the brains stem and hypothalamus, which modulate automatic and endocrine responses associated with emotive processing, and the hippocampus and parahippocampal regions, which play a role in the emotive learning and memory (Kilts et al., 2003; Strauss et al., 2005).

1.14 Event-Related Potential Correlates of Facial Processing

1.14.1 Face specific and emotive N170 ERP component.

A posterior temporal negative peak, N170, occurring ~170 ms following the presentation of a face is thought to reflect early visual structural encoding of faces prior to face recognition (Eimer, 1998; Vuilleumier & Pourtois, 2007). Indicated by source localization studies, the FFG/superior temporal gyrus has been suggested to be the likely source generator of the scalp N170 ERP (Eryilmaz et al., 2007). The N170 is specific to face stimuli processing, as non-face stimuli do not reliably elicit the N170. Further evidence has shown that irregularity of facial presentation (e.g., upside-down face) increases its latency, which is an index of cortical processing speed, suggesting the specificity of the N170 component to faces (McCarthy et al., 1999). However, the face-selective nature of the N170 has received some controversy, as Bentin and Colleagues (1996) found that isolated eyes versus whole faces elicited larger N170 amplitudes, where as other facial features (e.g. lips) resulted in attenuated N170 amplitudes relative to whole faces.

A number of studies have supported the notion that the amplitude and latency of the N170 is modulated by facial expression (Eimer et al., 2003; Holmes et al., 2003; Ashley et al., 2004; Santesso et al., 2008; Gonzalez-Garrido et al., 2009), whereas others have not (Blua, 2007). Studies have found fearful faces to elicit larger N170 amplitudes compared to surprised or neutral faces (Batty & Taylor, 2003; Eger et al., 2003; Stekelenburg & de Gelder, 2004). Angry faces have also been shown to enhance the N170 compared with happy faces (Krombholz et al., 2007). On the other hand, there is evidence that positive (versus negative) affective stimuli can modulate the N170. For example, Pizzagalli et al. (2002) found faces that were rated as most liked elicited greater activity in the FFG than less liked neutral faces. Additionally, Batty and Taylor (2003) found that positive emotions evoked N170 earlier than negative emotions, leading to suggestions that the intensity of the emotive expression (versus the facial expression) affects the N170 amplitude, where greater intensity will elicit greater N170 amplitude (Sprengelmeyer & Jentzsch, 2006).

1.14.2 Early latency ERP components.

Early rapid brain activity in response to facial expression of emotion has been suggested to be a detection of emotions, which may occur prior to face recognitions (Halgren et al., 2000; Pourtois et al., 2004; 2005), illustrated in Figure 5 ERPs occurring 80-90 ms following facial presentation have been found to be sensitive to both positive and negative emotive content (Eger et al., 2003; Brosch et al., 2008). The amplitude of first positivity (P100 [P1]) and the first negativity (N100 [N1]), occurring ~100 ms following the presentation of stimulus is a measure of an early attention allocation (Hillyard, Vogel, & Luck, 1998). The P1/N1 response to the emotive stimuli is indicative of an increase in attention directed toward the emotive images and would be expected to vary according to allocation of attention. The above pattern of activity has been suggested to support the idea that visual sensory processing of stimuli at an attended location is facilitated (Mangun & Hillyard, 1990), predicting that increased allocation of attention to emotional information (e.g., threat-related facial expressions) in anxious individuals should be associated with attention-related increase in the amplitude of these early ERP

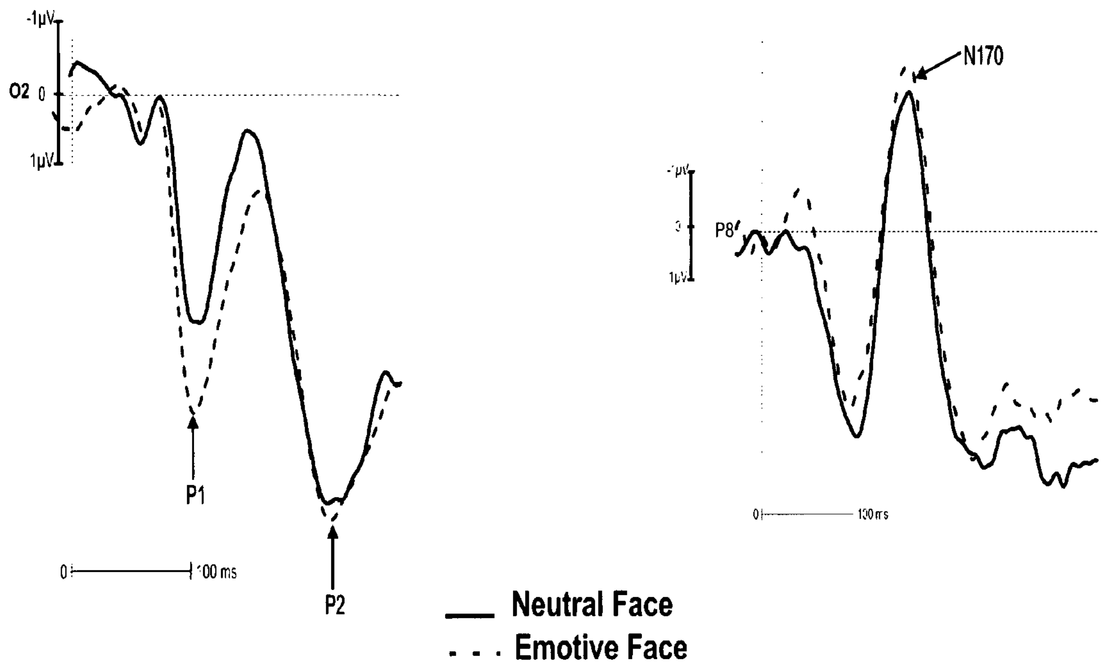


Figure 5. Example of grand averaged N170, P1 and P2 components during neutral and emotive face presentation.

components, or with faster P1 and N1 latencies, reflecting speeded capture of attention relative to non-anxious individuals.

1.14.3 Late latency ERP components.

ERP components elicited shortly after the N170 also appear to be sensitive to facial expressions of emotions (Liddell et al., 2004). A posterior positivity occurring ~200 ms after stimulus presentation has been suggested to reflect orientation to emotionally salient stimuli (Carretie et al., 2001). The P200 (P2) has been shown to be reduced by angry (Schutter et al., 2004) and by fearful expressions (Stekelenburg & de Gelder, 2004). However, others have shown enhancement of the P200 with facial expression of fear (Ashley et al., 2004), which is assessed in fronto-central regions. This suggests that the nature of the P200 modulation is dependent on where on the scalp these components are measured.

1.15 Facial ERP Components and Anxiety

Studies have investigated electrical brain activity during the processing of facial expressions in anxious individuals. However, these investigations have been primarily conducted with social phobia disorder patients. Using the dot probe task, high social-anxious individuals compared to low socially-anxious individuals showed a greater P100 amplitude and reduced N100 amplitude to angry facial stimuli (Helfinstein, White, Bar-Haim, & Fox, 2008). Holmes, Nielsen, and Green (2008) recorded ERPs from high- and low anxious individuals while participants were viewing centrally presented angry faces. High-anxious individuals showed greater P100 amplitude when viewing an angry face compared with low-anxious individuals. Researchers have reported somewhat larger occipito-temporal N170s to angry faces in socially anxious patients during an emotion identification task (Kolassa & Miltner, 2006) and an enhanced right-hemispheric N170 when the emotion of the angry face was the focus of attention (Kolassa & Miltner, 2006). In contrast, this same study reported no difference in P100 amplitude between social phobic, spider phobic, and non-phobic individuals in response to angry faces, although it was larger in response to emotional compared to neutral faces. Additionally, larger P1 amplitudes to angry-neutral versus happy-neutral face pairs in the dot-probe task was found in social anxiety disorder patients, but not controls. Social anxiety patients showed smaller P1 amplitudes to probes replacing emotional rather than neutral faces, and social anxiety patients reacted faster to probes replacing angry versus happy faces (Mueller, Hofmann, Santesso, Meuret, Bitran, & Pizzagalli, 2009). Surprisingly, there is a dearth of studies investigating electrical brain activity during the processing of facial expression in individuals with PTSD and the findings from the limited number of existing studies are inconsistent. Some studies with PTSD have reported no cortical hyper-reactivity to general threat stimuli (Casada, Amdur, Larsen et al., 1998), whereas other studies have reported higher N100 amplitude to sad stimuli (Ehlers, Hurst, Phillips et al., 2006). Due to small sample size (N = 15) and different methodologies used, these studies suggested further investigations are required to elucidate the cortical processing of PTSD patients while processing facial expressions.

The limited ERP data in PTSD is inconsistent with neuroimaging studies with fMRI that report greater amygdala activation to fearful faces in PTSD (Rauch, Whalen, Shim et al., 2000). Several of these studies have provided evidence consistent with amygdala hyperresponsivity during exposure to traumatic reminders in PTSD (e.g., Rauch, van der Kolk, Fisler et al., 1996; Pissiota, Frans, Fernandez et al., 2002) and have attempted to characterize the scope of amygdala hyperresponsivity in PTSD by determining whether amygdala responses to stimuli unrelated to trauma are also exaggerated in PTSD. Research on healthy individual has established that the amygdala is responsive to facial expressions of fear (Fredrikson, & Furmark, 2003; Morris, Frith, Perrett, et al., 1996) and that individuals with PTSD exhibit exaggerated amygdala responses to these facial expressions. Another fMRI study has reported increased amygdala activation in fearful faces in PTSD, suggesting a heightened reactivity to generic, biologically salient threats (Rauch, Whalen, Shin et al., 2000).

1.16 Why Angry and Fearful Faces?

The ability to recognize facial expressions is crucial for adaptive social interaction. Recognizing another's expression of rage or fear, for example, could allow for a rapid response to escape danger. In the present study, angry and fearful faces represent threatening, biologically salient stimuli. There is evidence that the amygdala is integral to rapid, adaptive response to fearful or angry faces (Phillips, Young, Senior et al., 1997). Given this, and the following three reason, fearful and angry faces were used as threatening stimuli: 1) according to subjective ratings for both types of faces, previous research has demonstrated that fearful and angry faces reflect equal levels of negative emotion and arousal (Johnsen, Thayer, & Hugdahl, 1995), as well as intensity (Ekman, Friesen, O'Sullivan, & Chan, 1987; Matsumoto, Kasri, & Kooken, 1999), 2) angry faces indicate immediate threat and fearful faces suggests the presence of a threat in the immediate environment (Whalen et al., 1998; Whalen et al., 2001). As fearful faces only indicate the presence of a threat, they are also more ambiguous than angry faces, which provide information about the specific source of a threat (Whalen et al., 1998), and 3) neuroimaging literature suggests that exposure to fearful faces activates the amygdala (Thomas et al, 2001; Monk et al., 2003) more than angry faces (Whalen et al., 2001). Given these reasons, attentional bias towards fearful and angry faces is the focus of the present study.

1.17 Objective and Hypotheses

As mentioned above, the imaging literature on amygdala activation and fear-potentiated startle has demonstrated that cognitive processes may interfere with or diminish emotional processing. This interference in emotional processing can in part be explained with the multiple resource theory, suggesting that performance decrements are observed due to resources being allocated to another task. Investigations have yet to be carried out on the effects of dual task interference on attentional bias to threatening stimuli. The objective of the present study is to utilize ERPs to non-invasively examine the neural correlates of: a) attentional bias towards anxiety provoking stimuli in PTSD versus healthy controls and b) to elucidate the differential effects of a secondary task on attentional bias towards anxiety provoking stimuli in controls and PTSD patients. Specifically, the present study aims to identify whether additional cognitive processes of attending to another task will interfere with attentional bias to threat provoking stimuli. Oddball auditory stimuli (standard and deviant tones) and dot-probe stimuli (face pairs followed by target probe) were presented concurrently for three conditions. One condition investigated attentional bias towards angry and fearful faces while ignoring the auditory modality and responding to the visual target bar probe (i.e., dot probe visual task: DPV), whereas the second condition investigated attentional bias towards angry and fearful faces while ignoring the visual modality and responding to the auditory target tone (i.e., dot probe task with auditory attend: DPA). The final condition investigated attentional bias towards the angry and fearful faces while attending to and responding to both (i.e., dot probe during dual task: DPD). These objectives were investigated with a mixed sample of PTSD patients compared to healthy controls. Assessments of subjective anxiety and valence/arousal ratings of emotional stimuli were carried out during all three conditions. On the bases of previous work with attentional load and attentional bias, the following hypotheses were proposed.

DPV condition.

In comparison to controls, individuals with PTSD were predicted to exhibit a) increased early processing of threat stimuli evidenced by increased amplitudes and shortened latencies of P1, N170 and P2 visual ERPs to threat (versus neutral) stimuli and b) increased attention allocation to threat (versus neutral) faces as evidenced electrophysiologically by enhanced P3b amplitude and decreased P3b latency to target of probes in the location of threat (versus neutral) faces. At the behavioral level we expected to observe greater response accuracy and faster responses, to these same target probes.

DPA condition.

Relative to the DPV condition, processes in the DPA task were predicted to be shifted towards auditory target detection, which would result in a larger P3b amplitude to the auditory target. Although evidence is mixed with respect to secondary task on emotional stimuli, it was predicted that early automatic processing of emotive stimuli would be attenuated and would exhibit decreased amplitudes and prolonged latencies of P1, N170 and P2 ERP components to threat (versus neutral) faces. These effects were expected to be observed for PTSD patients relative to healthy controls.

DPD condition.

Relative to both DPV and DPA conditions, the automatic processing of threat faces evidenced by P1, N170 and P2 ERP components was expected to be dampened in the DPD condition. Further, the processing of visual target probes replacing threat (versus neutral) faces was predicted to be attenuated in the DPD condition compared to the other two conditions as reflected by a smaller P3b amplitude, reduced response accuracy, and slower reaction time in target probes. The processing of auditory targets was predicted to be reduced in the DPD task compared to the DPA task (as evidenced by a smaller and slower P3b as well as by reduced performance accuracy and slower response speed to auditory deviants but augmented relative to that seen in the DPV task (as evidenced by a larger and shorter P3b). These effects were expected to be greater for the PTSD patients than the healthy controls.

For each of the above hypotheses, threat face visual field and hemisphere effects was expected to be observed. fMRI studies have shown an increased activation in the right hemisphere when processing facial stimuli. Some studies have shown bias to be only observed when the threat face appeared in the left visual field during the dot probe task, suggesting a hemispheric bias for processing threat face expressions. We expected a greater attentional bias to angry and fear faces when the threat face was presented in the left visual field. We expected sensory processing to fear and angry face pairs (versus neutral face pairs) to be greater in the right hemisphere.

2. METHOD

2.1 Study Volunteers

2.1.1 Experimental participants.

Twenty male volunteers who had a primary diagnosis of PTSD and had at least A1 criteria of traumatic events (defined by DSM-IV TR) were recruited from the Integrated Forensic Program at the Brockville Mental Health Centre. The trauma was deemed to be a significant contributor to the volunteer's psychiatric emotional and behavioural problem(s). Psychiatric diagnosis was made by study psychiatrists, according to Diagnostic and Statistical Manual of Mental Disorders (DSM)-IV-TR criteria. PTSD patients who scored at least 50 (moderate PTSD) on the Posttraumatic Stress Disorder Checklist – Civilian Version (PCL: Weathers et al., 1994) were included in the study. The patient's traumas included but were not limited to, sexual abuse, physical abuse, and observing a friends death. Patients were recruited in the study if they had Axis I and concurrent Axis II disorder, as long as their primary diagnosis was PTSD. Volunteers had an absence of acute psychotic, manic or delirium symptoms and absence of severe cognitive deficits. Participants were not included in the study if they had neurological disorders, including seizures and recent (< 6 months) head trauma, hearing loss of > 30 dB SPL and non-corrected vision. Volunteers were on a range of medication for their concurrent comorbid disorders (i.e., antidepressants, anti-anxiolytic).

2.1.2 Control participants.

Twenty (male) healthy controls (see Appendix I for power analysis for sample size) were recruited. The controls were similar to the PTSD group with regards to age, gender, and handedness. Control participants were interviewed to ensure absence of psychopathology, alcohol or drug abuse (assessed with an adapted structured clinical interview, non-patient version [SCID-NP]; First et al., 1996), history of seizure or significant brain trauma, and medications. Controls were also required to have normal hearing and normal or corrected vision. All participants signed an informed consent approved by the Royal Ottawa Health Care Group and Carleton University Research Ethic Boards.

2.2 Study Questionnaires/Ratings

All participants completed the following instruments once prior to the start of the study:

State-Trait Anxiety Inventory (STAI).

Trait anxiety was assessed with the trait portion of State-Trait Anxiety Inventory (STAI version Y; Spielberger et al., 1983) questionnaire on which participants rate their subjective trait anxiety on 20 symptoms. Values were summed to derive a score of 0-60, where the higher the score indicates greater trait anxiety (Spielberger et al., 1983).

The Edinburgh Handedness Inventory.

The Edinburgh Handedness Inventory (Oldfield, 1971) was used to assess the dominance of right or left hand use in everyday activities, where only individuals with right hand dominance were recruited into the study. The questionnaire consists of 12 items (e.g., cutting) that are rated based on hand-use. A Laterality Quotient was computed from the response, in which a score of 100 indicates right-hand dominance for all assessed items, while -100 indicates left-hand.

Profile of Mood States (POMS).

Mood was assessed with the Profile of Mood States (POMS; McNair et al., 1992) questionnaire on which participants rate their current subjective state using a 5 point Likert-type scale on 65 mood adjectives. Values were computed from the 65 mood adjective to form six mood dimensions (tension-anxiety [TA], depression-dejection[DD], anger-hostility [AH], vigor-activity [VA], fatigue-inertia [FI], confusion-bewilderment [CB]) as well as a total mood disturbance (TMD) score.

Beck Depression Inventory (BDI).

Depression was assessed with the Beck Depression Inventory (BDI; Beck et al., 1979) on which participants rated their intensity, severity, and depth of depression on 21 questions (with four possible responses), each designed to assess a specific symptom common among people with depression. A score from 0 to 9 represents minimal depressive symptoms, scores from 10-16 indicate mild depression, scores from 17-30 indicate moderate depression, and scores from 30-63 indicate severe depression.

Beck Anxiety Inventory (BAI).

Anxiety was also assessed with the Beck Anxiety Inventory (BAI; Beck et al., 1988), which consisted of 21 items, each describing a common symptom of anxiety (such as numbness, hot and cold sweats, or feeling of dread). Participants rated how much they were bothered by each symptom over the past week on a scale that ranged from "not at all", "mildly", "moderately" to "severely". The items were summed up to obtain a total score that ranged from 0-63.

Impact of Event Scale Revised (IES-R).

The Impact of Event Scale Revised (IES-R; Weiss & Marmar, 1997) was administered to PTSD participants to assess current subjective distress for any specific life event. The EIS-R consists of three subscales of posttraumatic stress reactions – Intrusion (7 items), Avoidance (8 items), and Hyperarousal (7 items). Participants were asked to indicate the frequency of each symptom during the past week on a 4-point-scale. The Intrusion and Hyperarousal subscales range between 0 and 35; the Avoidance subscale ranges between 0 to 40 (Weiss & Marmar, 1997)

2.3 Research Design

Experimental participants and healthy participants were assessed in one test session in which study measures were assessed during three conditions: a) visual dot probe task, b) auditory oddball tone discrimination task and c) dual visual auditory condition.

2.4 Session Procedures

Prior to arriving at their morning (8:00 a.m.) or afternoon (1:30 pm) test session, participants were instructed to abstain overnight (beginning at midnight) from nicotine, caffeine, alcohol, drugs and medications, and 1 hour from food. Upon arrival at the laboratory, participants completed a consent form and were seated in a comfortable chair in a sound attenuated room for the remainder of the session. Electrode application was followed by assessment during combined presentation of the visual dot probe task (DPV) and auditory oddball tone discrimination task (DPA) under three experimental conditions. Orders of task conditions were incomplete-counterbalanced across participants. Subsequent to the assessments, participants completed a self-report questionnaire regarding state anxiety and rated facial emotions for valence and arousal.

2.5 Experimental Conditions

Stimuli from the DPV and DPA paradigms were presented concurrently with ERPs and/or performance being assessed under three conditions: attend DPV condition, attend DPA, and attend DPV-DPA (the DPD condition). In the DPV paradigm, participants were instructed to ignore the auditory stimuli and respond only to visual target probes. In the attend DPA, they ignored DPV stimuli and responded only to DPA target auditory probes. In the combined condition, participants were instructed to respond to target probes in both the DPV and DPA paradigms.

Pairs of face stimuli derived from Gosselin et al. (1995) consisted of gray-scale photographs of male and female identities, each portraying a neutral, angry or fearful facial expression. Twelve grey scale photograph pairs of actors' faces displaying one of two expressions (fearful, angry) and a neutral expression were presented on a computer screen positioned ~one m in front of the seated participant. The faces measured 7.0 cm x 10.5 cm. Each emotion expression appeared equally often to the left or right of the fixation cross, situated in the center of the screen. Each face pair consisted of two different identities of the same sex portraying a neutral expression and either a fearful or angry emotional expression yielding three conditions: neutral-angry, neutral-fearful, and neutral-neutral. Each emotion was expressed at 100% intensity by one actor; two males and two females (i.e., 12 different actors were used). Expressions at 20% intensity were considered "neutral" as humans do not reliably distinguish facial expressions at this intensity (e.g. Orgeta & Phillips, 2008). The validity of these stimuli was previously established (Gosselin et al., 1995). Face stimuli were digitized and converted to grey-scale images, matched for luminance and contrast, with the neck, hair and background cropped out. All stimuli were set on a black background and presented on a 17 inch computer screen with a PC running Presentation Software.

2.5.1 DPV Condition

The task was a modified dot-probe task adapted from Meuller et al. (2009) and Pourtaois et al. (2004) with the addition of auditory stimuli presented concurrently. The task began with one practice block of 16 trials followed by five blocks of 80 trials (total 400 trials). Each block was separated by a short rest break. Practice trials consisted of pairs of emotionally neutral faces that were not be displayed again.

As shown in Figure 6, each trial began with the presentation of a fixation cross for 350 ms and then a face pair presented for 200 ms. A blank screen with a fixation cross appeared following the presentation of a face pair, which was randomly presented for 350-600 ms (increments of 50 ms). The probe (avertical bar) appeared for 150 ms in either location previously occupied by a face with an inter-trial interval was 1850-2100 ms. Fearful and angry faces appeared equally often and with equal frequency in the right

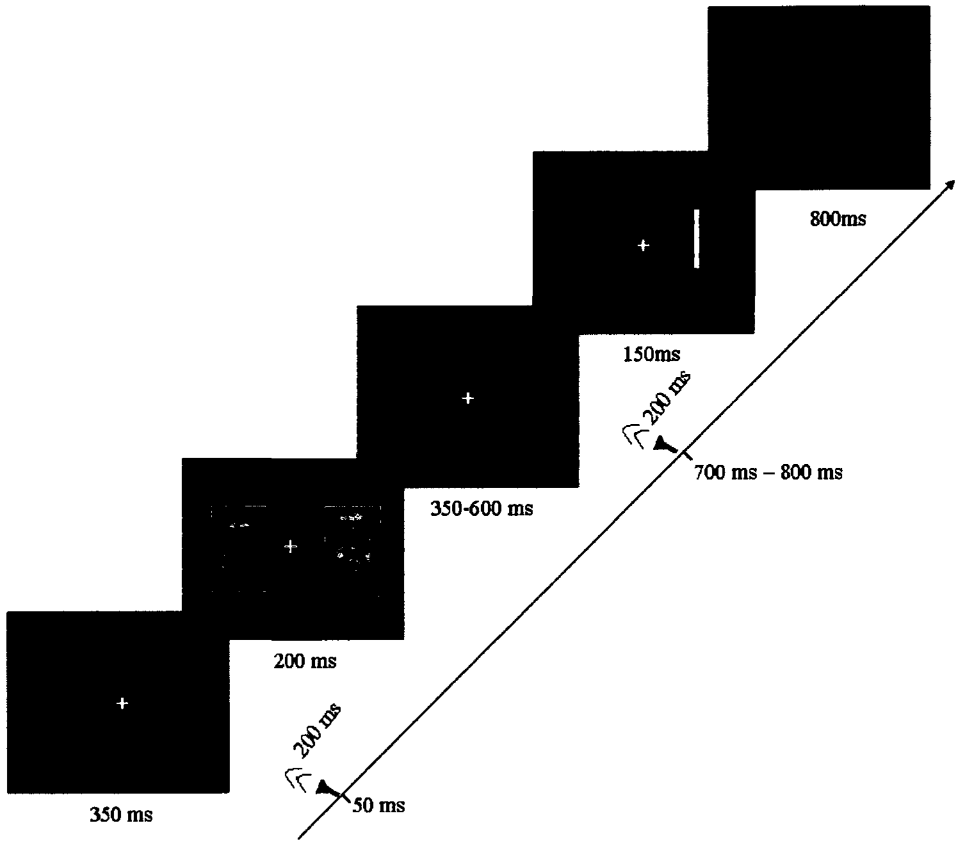


Figure 6. Schematic of the paradigm.

visual field or left visual field. All stimuli were randomized and counterbalanced across participants.

Binaural auditory tones (200 ms duration, 5 ms rise/decay, 75dB SPL) were presented through headphones 50 ms following the onset of each trial (300 ms prior to face pairs) and 350-600 (increments of 50) ms prior to the visual probe. Standard tones (1200 Hz) were presented more frequently ($p = .90$) than deviant (1000 Hz) tones ($p = .10$). The deviant tone was equally presented prior to the facial pair ($p = .05$) and the target probe ($p = .05$). Participants were instructed to ignore the auditory tone stimuli and respond only to the target probe.

Participants were instructed to press either the right key or left key button on the response pad, as quickly and accurately as possible (with index finger of dominant hand), when they detected the bar probe on the right or left side of the screen, respectively, while ignoring the auditory target probe. Trials with response times that were <100 and >900 ms from onset of the probe were excluded from the analyses. These cut off were used to prevent the inclusion of trials with reaction times that carried over to the next trial. Behavioural measures included reaction times (ms) and percentage of correct response (hits), defined as a key press within 100 to 900 ms after probe onset and reaction times (ms) of correct responses.

2.5.2 DPA Condition

The DPA condition included the same stimuli presentations as the DPV with the exception that participants responded to the auditory target probes while ignoring the visual bar probes. Participants were instructed to press the bottom button on the response pad as quickly and as accurately to the deviant tone while fixating on the center of the screen.

2.5.3 DPD Condition

This involved the same stimulus presentation as the DPV and DPA with the exception that the participants responded to both the auditory target probes and the bar probes. Participants were instructed to press the right and left key on the response pad when they saw the bar probes and heard the auditory target probes, respectively.

2.6 Electrophysiological Assessments

2.6.1 ERP Recordings.

Participants were instructed to sit upright and keep movements, including blinking, to a minimum during the ERP assessments. During the three conditions, electrical activity was recorded with a cap-embedded with Ag+/Ag+-Cl ring electrodes (EasyCap®, Herrsching-Breitbrunn, Germany) at 8 scalp sites positioned according to the 10-10 system of electrode placement. Electrical activity was recorded from the central sites (Fz, Cz, Pz, and Oz), occipital sites (O_1 and O_2) and the temporal-occipital sites (P_7 and P_8). Additional electrodes were placed on the supraorbital ridge and the suborbital ridge of the right eye and on the canthus of both right and left eyes to monitor electrooculographic (EOG) activity and subsequently minimize contamination from eye movements and blinks. An electrode was attached to the nose to serve as the reference and a frontally positioned electrode served as the ground. Electrode impedances were maintained at less than 5kΩ and electrical activity was sampled at 500 Hz. The electrical signals was amplified with a bandwidth filter set at 0.1-70 Hz and the on-line computerized analog-to-digital sampling rate time-locked to each stimulus presentation was carried out for a 1000 ms epoch beginning 100 ms prior to stimulus onset.

Behavioural measures included reaction times (ms) and percentage of correct response (hits), defined as a key press within 100 to 900 ms (after target tone onset) and reaction times (ms) of correct responses.

2.6.2 ERP Processing.

During off-line signal processing, four analytical procedures were applied to the stored digitized recordings: (1) ocular correction software algorithm (Gratton, Coles, Donchin, 1983) was employed to correct EEG recordings for eye movements/blinks; (2) corrected trial epochs with EEG voltages greater than ±100μV were eliminated from further analysis. (3) individual trials were filtered at 0.1-30.0 Hz to reduce the contamination of high frequency (60 Hz) electrical noise on waveform component identification and measurement and (4) filtered trials were averaged and baseline corrected with respect to 100 ms pre-stimulus activity.

2.6.3 ERP Measures.

Relevant ERP components were identified based on the viewing of grand-averaged waveforms constructed from all stimulus pairs and probes. The facial pair amplitude measurement guidelines for P100 were based on previous work by Mueller et al. (2009) and Pollak and Tolley-Schell (2003). The measurement guidelines for the face specific N170 was base on previous work by Santesso et al. (2008).

2.9.3.1 Facial ERPs.

P100 elicited by the face pairs (P1-face) was measured as the largest average peak positive voltage ±5 time points around the peak value, within the time window of 75-150 ms following face onset. P100 and its latency (time from face pair onset to peak in ms) was derived at the parietal-occipital sites (P_7 and P_8), the sites of maximal amplitude.

The face specific N170 was measured (at P_7 and P_8) as the largest average peak negative ±5 voltage points around the peak value within the time window of 130-210 ms following face pair onset at left and right occipital temporal sites. P200 elicited by the face pairs (P2-face) was measured (at P_7 and P_8) as the largest average peak positive ±5 voltage points around the peak value within the time window of 240-240 ms following face pair onset. Latencies of each of these peaks were measured in the same manner as P1.

2.9.3.1 Dot Probe ERPs.

P300b elicited in response to the bar probe (P3b-bar probe) was measured as the largest average peak positive ±5 voltage points around the peak value, within the time window of 250-500 ms following bar probe onset. P300b amplitude and its latency were derived at the parietal site (P_z), the site of maximal amplitude.

3.9.3.2 Auditory ERPs.

P300b elicited in response to the auditory target probe (P300b-auditory) was also measured. P300b was measured as the largest average peak positive ±5 voltage points around the peak value within the time window of 300-600 ms following auditory target probe onset. P300b amplitude and its latency were derived at the parietal site (Pz), the site of maximal amplitude.

2.7 Behavioural Performance

In both the DPV and DPA response accuracy was assessed by measuring percentage correct responses (Hits: key presses to target stimuli within 100-1000 ms) and percentage incorrect Responses (FA: key presses to non-target stimuli), and response speed was measured by reaction time (RT) to correctly detected targets.

2.8 Questionnaires

Participants completed the following instruments three times, at the end of each condition.

State Anxiety.

State anxiety was assessed from the State portion of State-Trait Anxiety Inventory (STAI version Y; Spielberger et al., 1983) on which participants rated their subjective state anxiety on 20 symptoms. State anxiety results in a score of 0-60, where the higher the score indicates greater anxiety (Spielberger et al., 1983). This assessment was taken after each of the three task conditions.

2.9 Facial Ratings

Using 9 point (1-9) visual analogue scales, participants were asked after each of the three task conditions to rate their own personal experience to each face with respect to valence (i.e., "How unpleasant/pleasant is this picture?"), and emotional arousal ("How intense is this picture?").

2.10 Statistical Analysis

Statistical analysis consisted of separate (for each dependent variable) mixed Analysis of Variance (ANOVA) using the Statistical Package for Social Sciences (SPSS 17.0). Planned pairwise comparisons (Bonferroni-adjusted) of group x condition x face type x face field x hem (or probe-position) were carried to evaluated study-specific hypotheses for face pair ERPs, bar probe ERPs, and bar probe performance measures.

The analysis for the face pair ERPs measure consisted of 2 (group: controls vs. PTSD) x 3 (condition; DPA vs. DPV vs. DPD) x 3 (face pair: angry-neutral vs. fear-neutral vs. neutral-neutral pair) x 2 (face field: threat face presented either on the right visual field vs. left visual field) x 2 (hemisphere: left hemisphere [P_7] vs. right hemisphere [P_8]). The analysis for the bar probe ERPs and performance measures (reaction time, percentage correct responses and incorrect response) included the same factors as mentioned above (2 [group] x 2 [condition: PDV vs. DPD] x 3[face pair] x 2 [face field]) with the exception of hemisphere factor and with the inclusion of bar probe position (2: [congruently cued] probe replacing threatening face position vs. [incongruently cued] probe replacing neutral face position) factor.

Mixed ANOVA was conducted for the auditory deviant ERP and performance measures (reaction time, percentage correct responses and incorrect response) that included 2 (group) x 2 (condition: DPA vs. DPD) factors. Significant Greenhouse-

Geisser ($p < .05$) ANOVA effects were further examined with Bonferroni-adjusted pair-wise comparisons.

Separate ANOVAs, used to compare the two study groups, were carried out on the TA dimension of the POMS, trait anxiety scores, BDI scores, as well as BAI scores. Additionally, a mixed ANOVA was conducted to compare state anxiety scores and subjective ratings across the three conditions (DPA vs. DPV vs. DPD) and between the two groups.

3. RESULTS

3.1 Demographic, Clinical and Mood Measures

Mean group values for demographic variables as well as for anxiety, depression, mood and clinical ratings are presented in Table 1. The HC group was found to have more schooling than the PTSD group, F (1, 38) = 58.61, p < .05. Compared to the HC group, the PTSD participants also exhibited higher ratings on self-report clinical instruments of depression (BDI), F (1, 38) = 67.98, p < .001, and anxiety (BAI), F (1, 38) = 89.52, p < .001, which were accompanied by greater trait anxiety scores, F (1,38) = 4.44, p < .05, and all of the mood dimension, including the TMD, scores as assessed with the POMS (p < .05). The self-reported PTSD symptoms scores, assessed with the IES, showed that all symptom cluster ratings were in the moderate impact range. These group differences on the clinical ratings were expected given that the HC group was screened to have no psychiatric history.

3.2 Visual Dot Probe Task

For each of the performance and ERP measures Bonferroni-adjusted planned comparisons probing the attentional bias effects between and within groups are presented. Note, that right and left visual field refers to the location of the threat face (either angry or fear) on the computer monitor. For example, a statement including right visual field angry-neutral face pairs indicates that the angry face is presented in the right visual field and the neutral face is presented in the left visual field.

Table 1. Mean (±*SE*) group values for demographic variables, and anxiety, depression, mood, and clinical ratings.

		PTSD Group	HC Group
	Age	35.50 (1.90)	32.25 (1.90)
	Education *	11.35 (0.47)	16.48 (0.47)
	BDI *	26.95 (2.12)	2.20 (2.12)
	BAI *	30.80 (2.02)	3.8 (2.02)
	Trait Anxiety *	47.10 (0.87)	44.55 (0.87)
POMS			
	Depression-Dejection (DD) *	28.61 (1.74)	4.19 (1.74)
	Vigor-Activity (VA) *	13.11 (1.27)	18.35 (1.27)
	Confusion – Bewilderment	13.16 (0.81)	5.00 (0.81)
	Fatigue-Inertia (AH) *	13.12 (1.09)	6.20 (1.09)
	Anger-Hostility (AH) *	17.06 (1.79)	5.31 (1.79)
	Tension-Anxiety (TA) *	18.06 (1.34)	5.56 (1.37)
	TMD *	76.89 (5.97)	8.13 (5.96)
PCL		59.65 (1.64)	-
IES			
	Avoidance	19.56 (1.29)	-
	Intrusions	17.90 (1.09)	-
	Hyperarousal	16.29 (1.40)	-
	IES Total	53.75 (3.89)	-

HC: Healthy Controls; BAI: Beck Depression Inventory; BAI: Beck Anxiety Inventory; TMD: Total Mood Dimension; PCL: Posttraumatic Stress Disorder Checklist – Civilian Version; IES: Impact of Event Scale Revised.
*Significant group difference ($p < .05$)

3.2.1 Percentage Correct (Hits)

Planned comparisons were carried out to examine the specific study hypothesis regarding group, condition, face, face field and probe-position (congruently cued: probe replacing either angry or fear face; incongruently cued: probes replacing neutral face) differences. Planned pairwise comparisons of group×condition×face field×probe-position×face pair interaction revealed that during the DPD (visual and auditory attend task; dot probe dual) condition the PTSD group showed greater percentage hits to congruently cued probes replacing angry-neutral (M = 98.50%, SE ± 0.43; $p < .05$) and fear-neutral (M = 98.13%, SE ± 0.82; $p < .05$) face pairs in the right visual field compared to the neutral-neutral (M = 96.57%, SE ± 1.11) face pairs (an expected attentional bias [vigilance] effect). During the same condition and in the same group, percentage hits to congruently cued probes replacing fear-neutral (M = 98.08, SE ± 0.55) in the left visual field was greater ($p < .001$) than left visual field neutral-neutral (M = 96.72 SE ± 0.78) face pairs (an attentional bias [vigilance] effect). This effect was not observed in the DPV (visual task alone; dot probe visual) condition and the HC group failed to exhibit any of these performance accuracy indicators of attentional bias (Figure 7).

3.2.2 Percentage Incorrect Response

Planned pairwise comparisons of a non-significant group×condition×face field×probe-position×face pair interaction revealed that during both conditions, when threat face was presented in either visual field, and both probe-positions, neutral-neutral face pairs resulted in greater ($p < .05$) percentage incorrect responses to probes than did

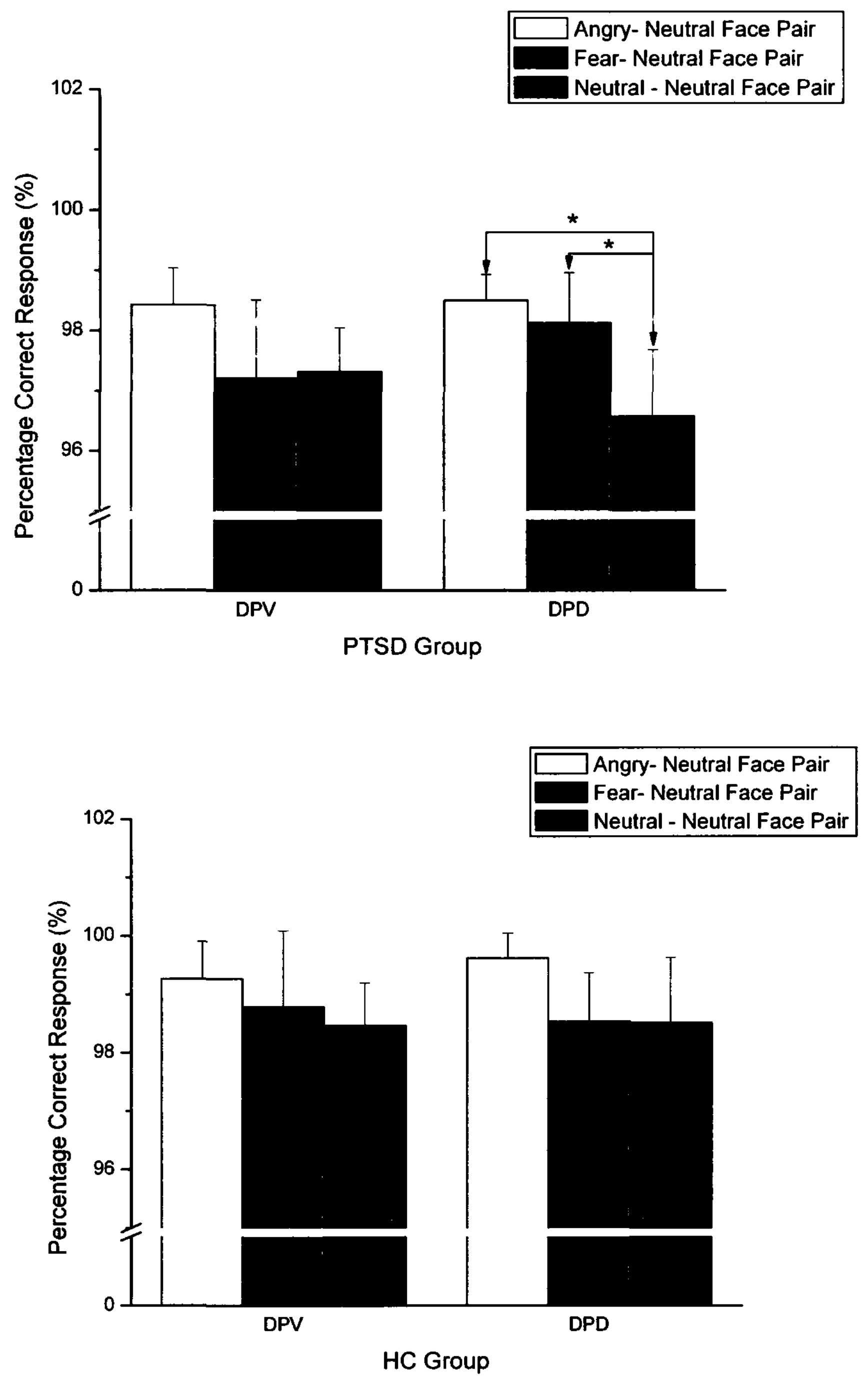
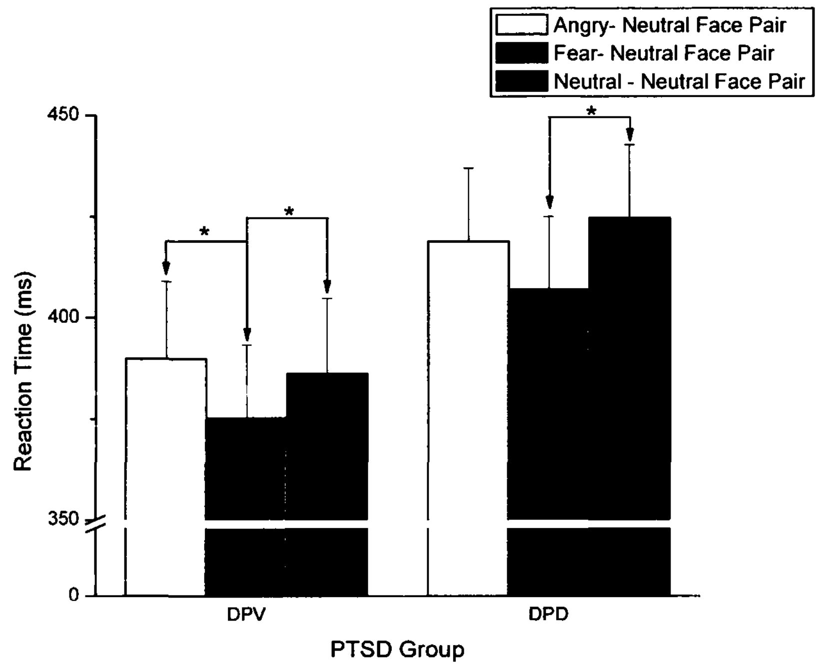


Figure 7. Mean (± *SE*) percent correct response (% Hits) to congruently cued probes following right visual field presentation of angry-neutral, fear-neutral and neutral-neutral face pairs in PTSD and HC groups during DPV and DPD conditions. * $p < .05$

angry-neutral and fear-neutral face pairs in the PTSD group. In the HC group this effect was only observed in the DPV condition when the angry face was presented in the right visual field and the probe was congruently cued ($p < .05$; an attentional bias [vigilance] effect) and when the angry face was in the left field and the probe was incongruently cued ($p < .05$).

3.2.3 Reaction Time (RT)

Planned pairwise comparisons of a non-significant task condition×face pair×face field×probe-position×group interaction found slower ($p < .05$) RTs for the PTSD group (M = 411.49 ms, SE ± 15.90) compared to the HC group (M = 360.87 ms, SE ± 15.50) during the DPD condition when the congruently cued probe replaced right visual field presentation of angry-neutral face pairs. Within group comparisons during the DPV condition indicated that in the PTSD group the RT to incongruently cued probes replacing right visual field presentation of fear-neutral face pairs (M = 375.31 ms, SE ± 18.07) was faster compared to incongruently cued probes replacing right angry-neutral face pairs (M = 389.86 ms, SE ± 17.01) as well as neutral-neutral (M = 386.21 ms, SE ±18.60) face pairs (an expected attentional bias [avoidance] effect). Similarly, during the DPD condition the PTSD group also responded faster ($p < .05$) to the incongruently cued probes replacing right visual field fear-neutral face pairs (M = 407.03 ms, SE ± 7.94) compared to the neutral-neutral (M = 427.70 ms, SE ± 18.09) face pairs (an unexpected attentional bias [avoidance] effect). These two effects were not seen in HC (Figure 8). A general condition effect was observed in the PTSD group (p <.05) whereby the DPV condition resulted in a faster RT than in the DPD condition. The same condition effect



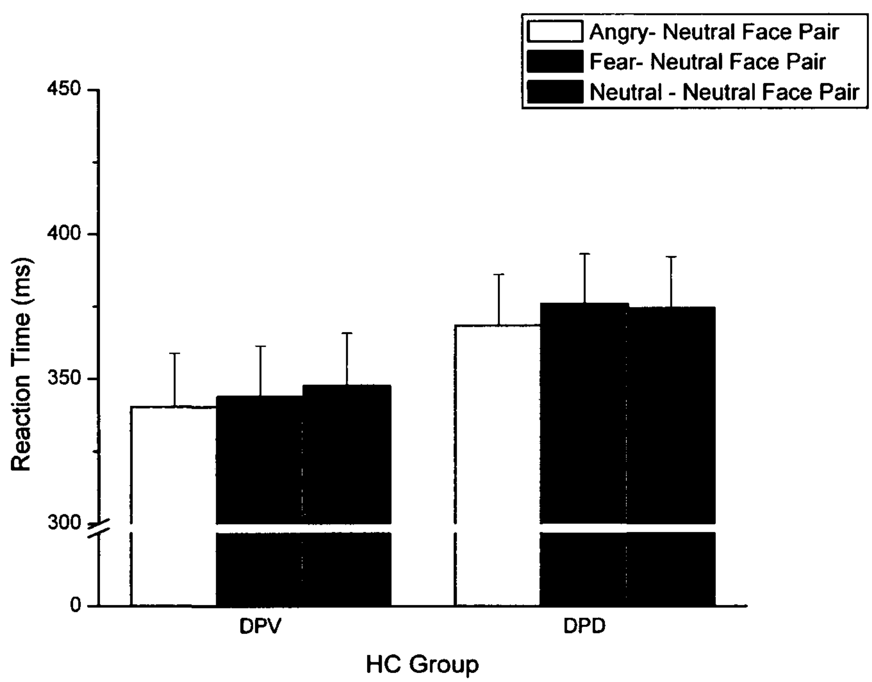


Figure 8. Mean (± *SE*) reaction time (ms) to incongruently cued probes following right visual field presentation of angry-neutral, fear-neutral and neutral-neutral face pairs in PTSD and HC groups during DPV and DPD conditions. * $p < .05$

($p < .05$) was observed in the HC group, except when they were responding to congruently cued probes replacing left visual field angry-neutral face pairs.

3.2.4 Probe P300 Amplitude

Planned pairwise comparisons of a non-significant condition×face pair×face field×probe-position×group interaction revealed group differences. During the DPV condition a larger ($p < .05$) P300 amplitude to congruently cued probes replacing left visual field fear-neutral face pairs was observed in the HC group (M = 10.63 μV, SE ± 1.25) compared to the PTSD group (M = 7.04 μV, SE ± 1.25) (Figure 9). Specifically, within the PTSD group during the DPV condition, P300 amplitude to congruently cued probes replacing neutral-neutral face pairs (M = 12.00 μV, SE ± 1.60) was larger ($p < .05$) than replacing right visual field fear-neutral (M = 8.20 μV, SE ± 1.26) face pairs (an unexpected attention bias [avoidance] effect). However, in the same group during the same condition, P300 amplitude to incongruently cued probes replacing neutral-neutral face pairs (M =12.00 μV, SE ± 1.60) was larger ($p < .05$) than with right anger-neutral (M = 8.09 μV, SE ± 1.03) face pairs (an unexpected attentional bias [disengagement] effect; Figure 10). This effect was not observed within the HC group. Additionally, the PTSD group during the DPV condition exhibited a larger ($p < 0.5$) P300 amplitude to congruently cued probes (M = 1065 μV, SE ± 1.39) compared to incongruently cued probes (M = 8.09 μV, SE ± 1.03) replacing right visual field angry-neutral face pairs (an expected attentional bias [vigilance] effect). However, during the DPD condition the PTSD group showed a larger ($p < .05$) P300 amplitude to incongruently cued probes (M = 8.97 μV, SE ± 1.11) compared to congruently cued probes (M = 6.16 μV, SE ± 1.19)

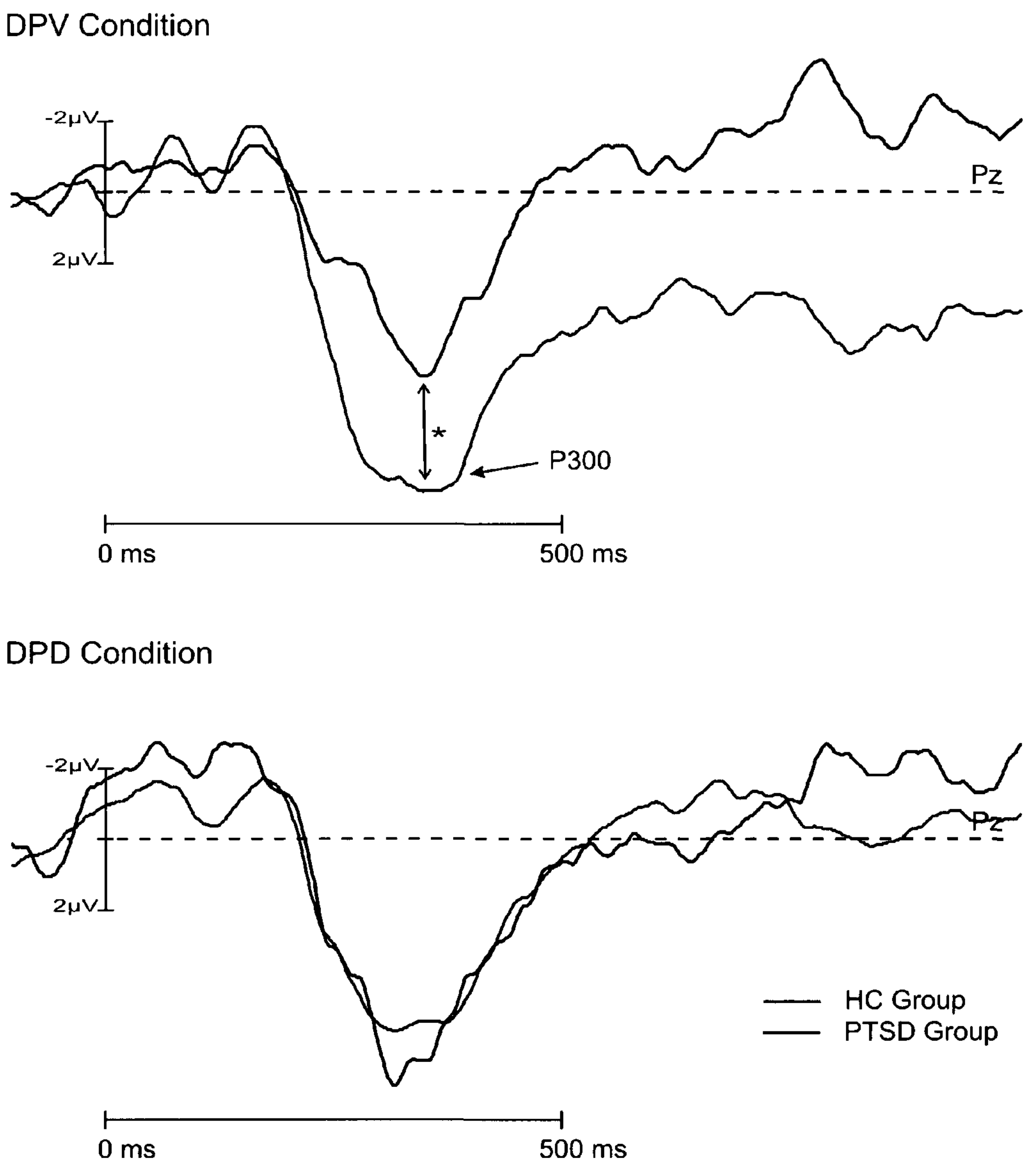


Figure 9. Grand averaged P300 amplitude waveforms for PTSD and HC group in response to congruently cued probes replacing left visual field fear-neutral face pairs during DPV and DPD conditions. * $p < .05$

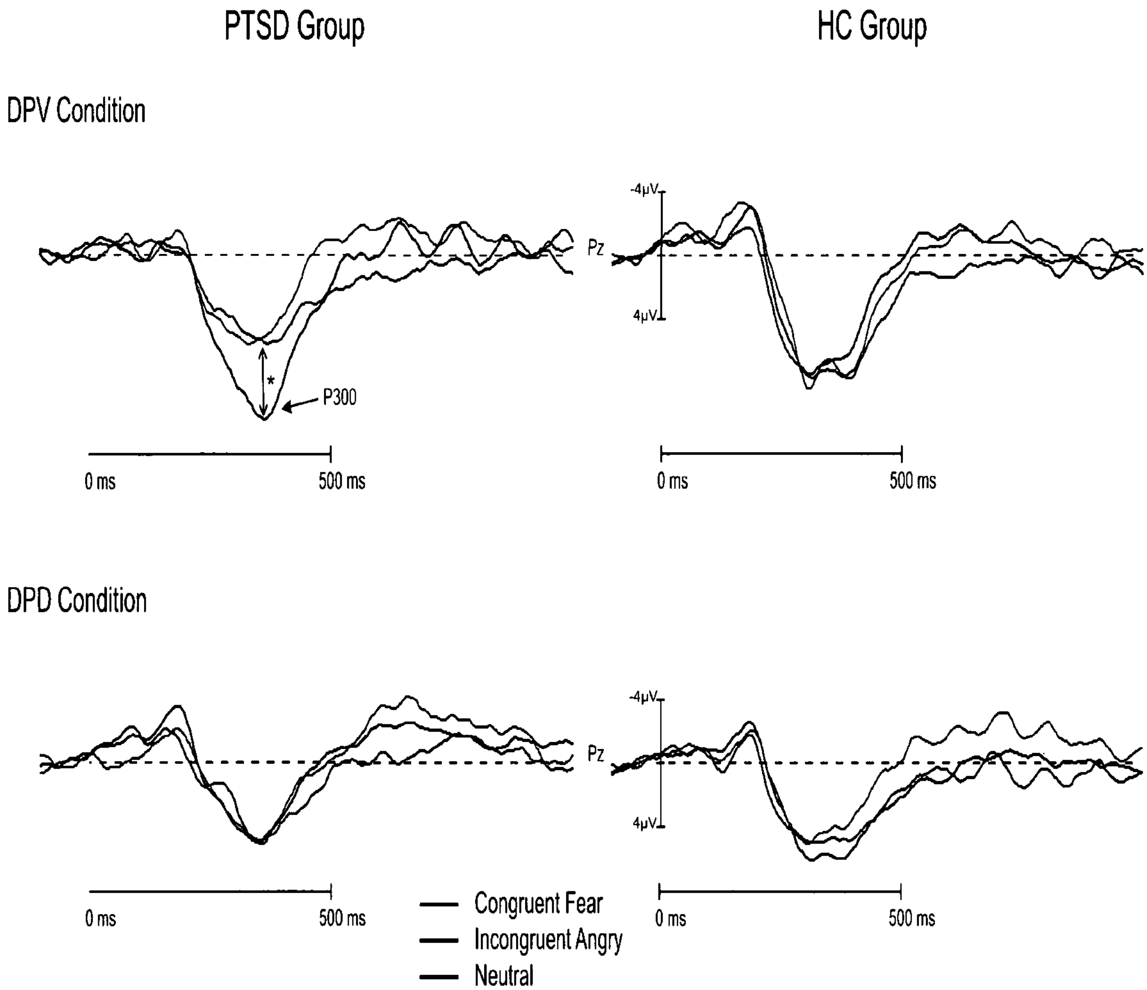


Figure 10. Grand averaged P300 amplitude waveforms in HC and PTSD groups in response to probes replacing neutral-neutral face pairs, congruently cued probes replacing right field fear-neutral face pairs and incongruently cued probes replacing right field angry-neutral face pairs during DPV and DPD conditions. * $p < .05$

replacing left visual field angry-neutral face pairs (an unexpected attentional bias [avoidance] effect). The differences in probe-position were not observed in the HC group (Figure 11). Condition effects were also observed (DPV larger than DPD) and were generally seen regardless of face field, though in the PTSD group these effects were seen with congruently cued anger-neutral and neutral-neutral face pairs ($p < .05$), while in the HC group they were observed following congruent angry-neutral and incongruent fear-neutral face pairs, but not neutral-neutral face pairs.

3.2.5 Probe P300 Latency

Planned pairwise comparisons of a non-significant condition×face pair×face field× probe×group interaction revealed that during the DPD condition a shorter ($p < .05$) P300 latency to probes replacing neutral-neutral face pairs was observed for the PTSD (M = 322.40 ms, SE ± 13.25) compared to the HC group (M = 364.60 ms, SE ± 13.25). Specifically during the DPD condition P300 latency was shorter ($p < .05$) to the incongruently cued probes replacing left visual field fear-neutral face pairs (M = 331.20 ms, SE ± 12.90) compared to neutral-neutral (M = 373.90 ms, SE ± 16.51) face pairs within the PTSD group (an unexpected attentional bias [avoidance] effect; Figure 12). Additionally, during the DPV condition, shorter ($p < .05$) P300 latency was observed when right visual field fear-neutral face pairs were replaced by congruently (M = 321.37 ms, SE ± 13.19) compared to incongruently cued probes (M = 351.47 ms, SE ±13.36) in the PTSD group (an expected attentional bias [vigilance] effect). During the DPD condition, PTSD patients also revealed a shorter ($p < .05$) P300 latency when right visual

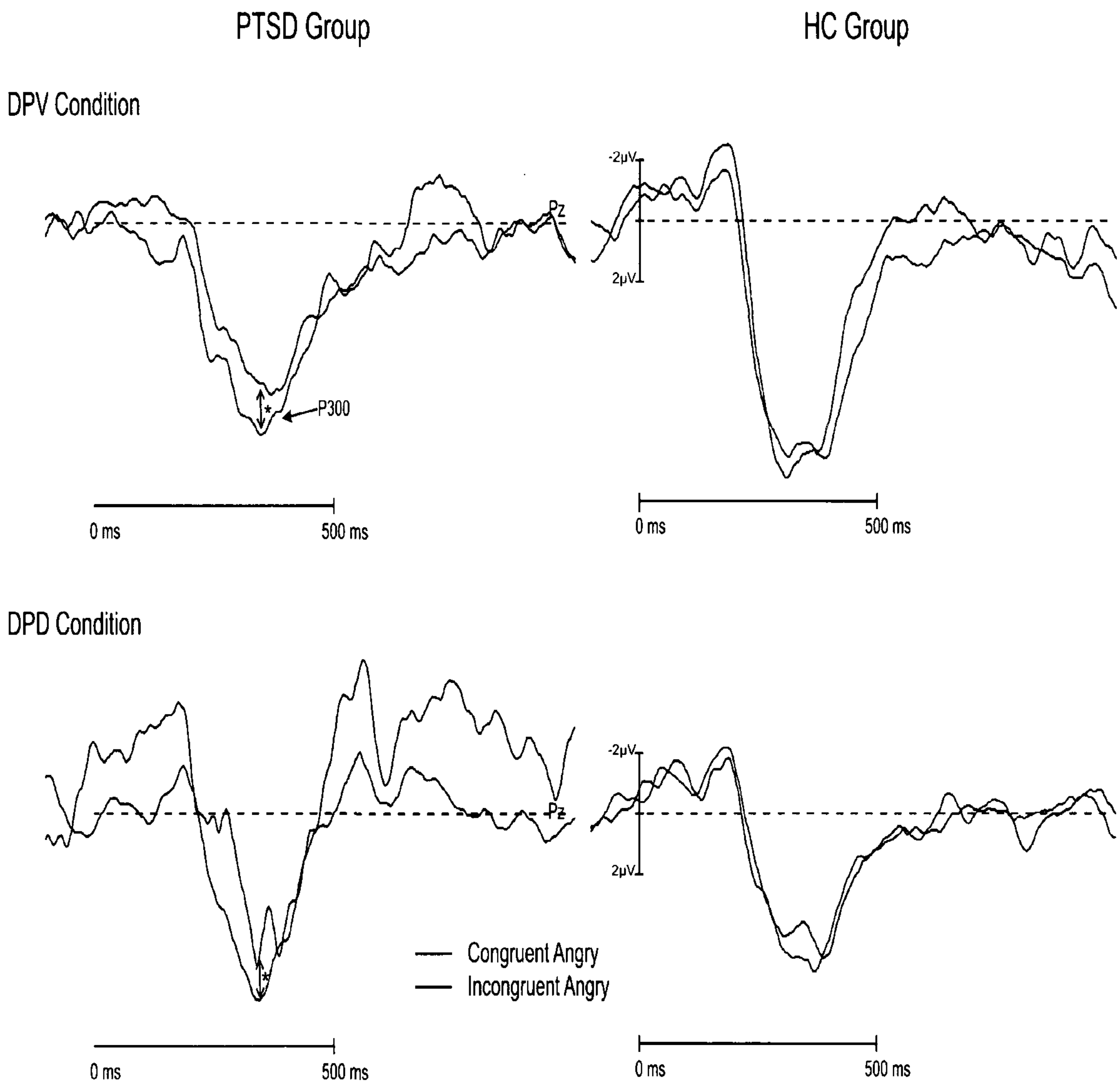


Figure 11. Grand averaged P300 amplitude waveforms to congruently and incongruently cued probes replacing right field (for the DPV condition) angry-neutral face pairs and left field (for the DPD condition) angry-neutral face pairs in PTSD and HC groups. * $p < .05$

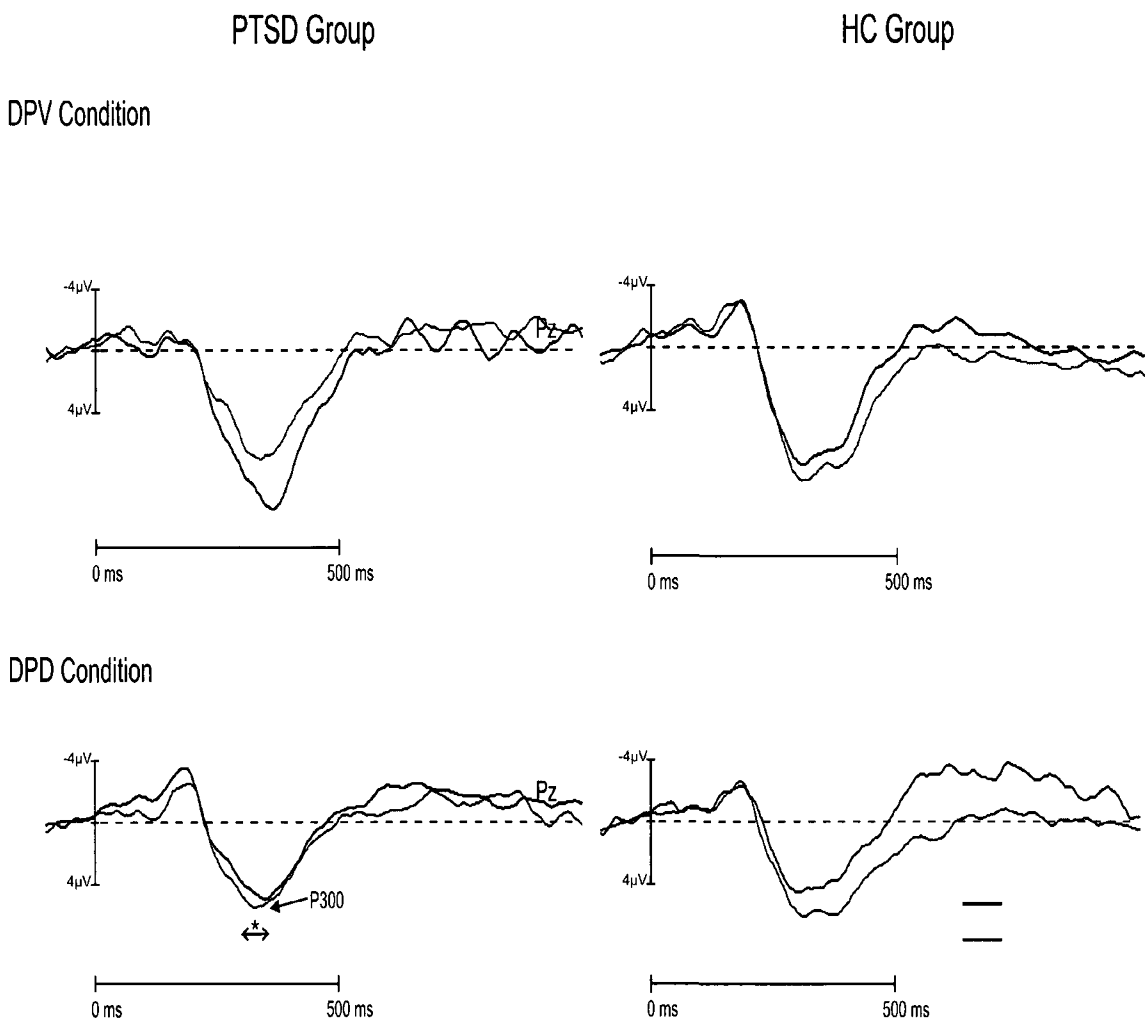


Figure 12. Grand averaged P300 waveforms in PTSD and HC groups during DPV and DPD conditions. Shorter latencies were evident in the PTSD group during DPD for incongruently cued probes replacing left visual field fear-neutral face pairs compared to neutral-neutral face pairs. * $p < .05$

field angry-neutral face pairs were replaced with congruently (*M* = 329.69 ms, *SE* ± 12.97) compared to incongruently cued probes (*M* = 360.40 ms, *SE* ± 14.26) (an expected attentional bias [vigilance] effect; Figure 13) and when left visual field fear-neutral face pairs were replaced with incongruently (*M* = 331.20 ms, *SE* ± 12.90) compared to congruently (*M* = 370.40 ms, *SE* ± 15.27) cued probes (unexpected attentional bias [avoidance] effect; Figure 13). Lastly, during the DPD condition the PTSD group revealed shorter ($p < .05$) P300 latency to incongruently cued probes replacing left (*M* = 331.20 ms, *SE* ± 12.90) compared to right field (*M* = 361.00 ms, *SE* ± 14.63) fear-neutral face pairs.

3.3 Face ERPs

3.3.1 P100 amplitude

Planned pairwise comparisons of a non-significant condition×face pair×face field×hemisphere×group interaction exhibited larger right hemisphere P100 amplitude in the HC group (*M* = 3.82 μV, *SE* ± 0.47) compared to the PTSD group (*M* = 1.98 μV, *SE* ± 0.47) to right visual field angry-neutral face pairs during the DPA condition ($p < .05$). During the DPA condition, the PTSD group exhibited larger ($p < .05$) right hemisphere P100 amplitudes to left visual field angry-neutral (*M* = 3.20 μV, *SE* ± 0.49) face pairs compared to neutral-neutral (*M* = 2.14 μV, *SE* ±0.43) face pairs (an expected attentional bias [vigilance] effect; Figure 14). Under the DPV condition, the PTSD group exhibited

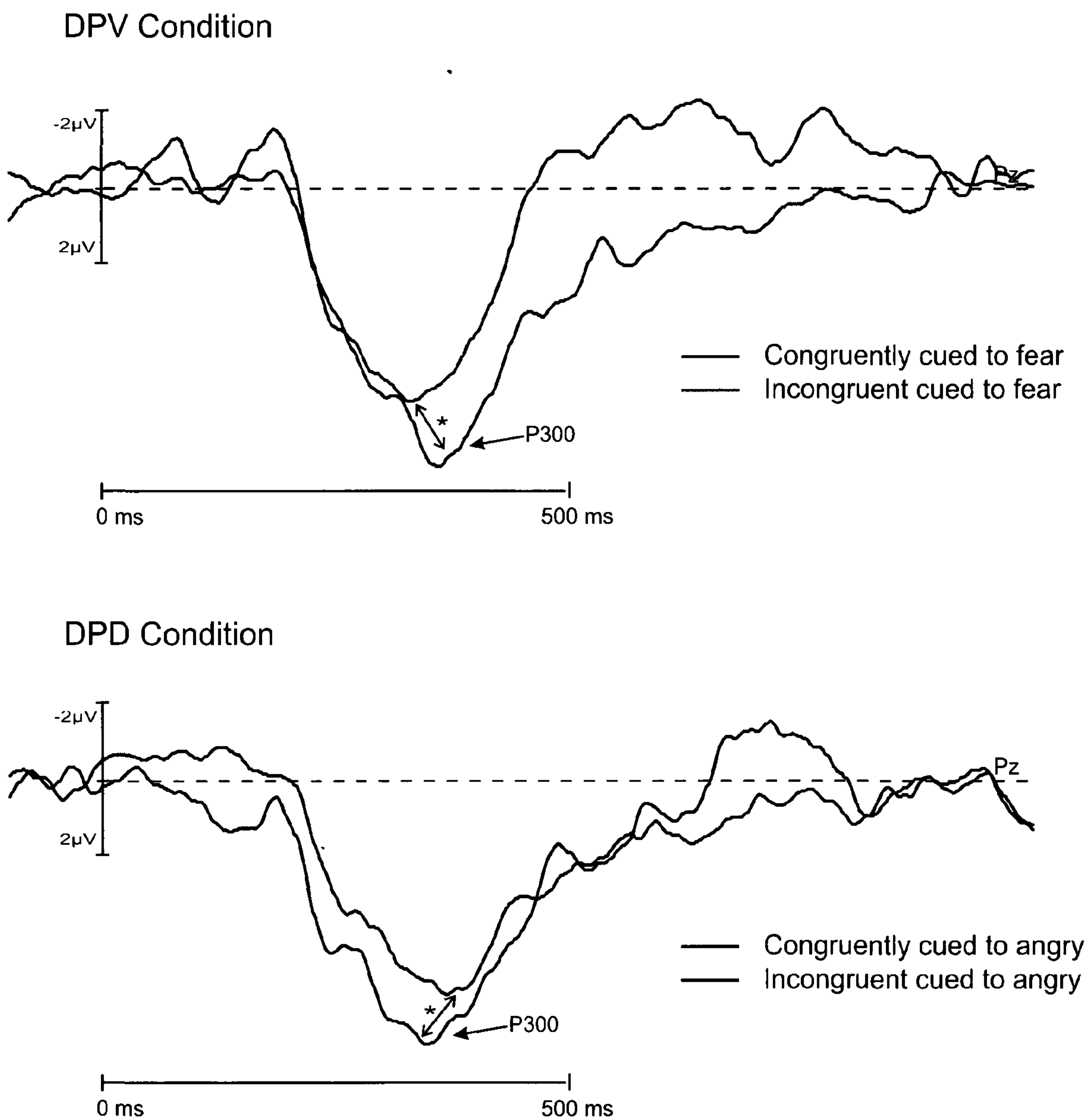


Figure 13. Grand averaged P300 waveforms in the PTSD group during DPV and DPD conditions. Compared to incongruently cued probes, shorter P300 latencies were evident for congruently cued probes replacing right visual field fear-neutral face pairs (DPV condition) and congruently cued probes replacing right visual field angry face pairs (DPD condition). * $p < .05$

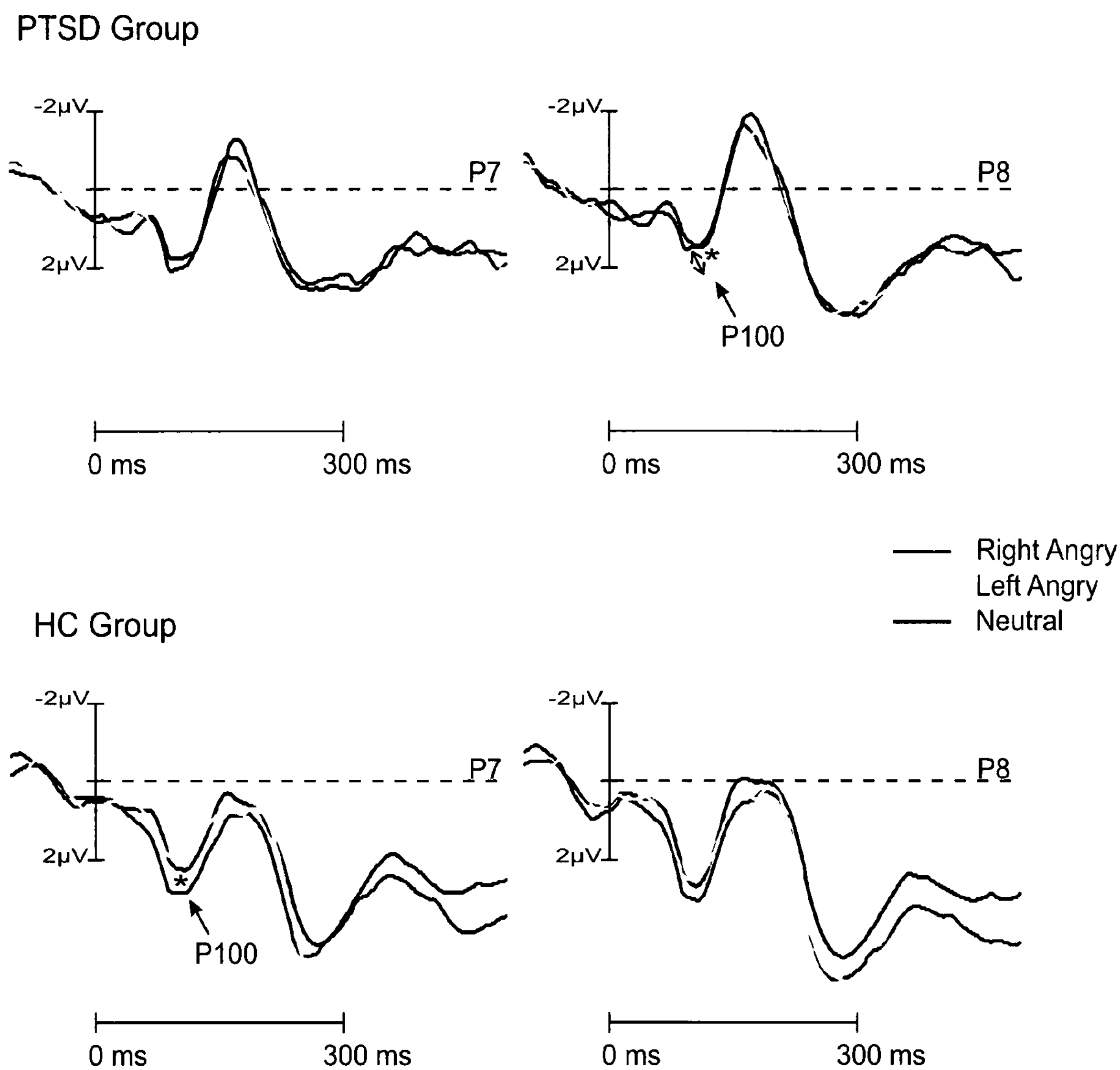


Figure 14. Grand averaged P100 amplitude waveforms to left and right visual field angry-neutral face pairs in the PTSD and HC groups during the DPA condition. * $p < .05$

larger ($p < .05$) left hemisphere P100 amplitudes to neutral-neutral face pairs (M = 2.64 μV, SE ± 0.57) compared to left fear-neutral (M = 1.70 μV, SE ± 0.57) face pairs (an unexpected attentional bias [avoidance] effects; Figure 15). However, under the DPA and DPV conditions, the HC group exhibited larger ($p < .05$) left hemisphere P100 amplitudes to right visual field angry-neutral face pairs (M = 3.63 μV, SE ± 0.47) as well as to right visual field fear-neutral face pairs (M = 2.95 μV, SE ± 0.54) compared with neutral-neutral face pairs (M = 2.67 μV, SE ± 0.45) (an attentional bias [vigilance] effect; Figure 14 and 15). Condition effects were observed in both groups and although they varied with threat face visual field and hemisphere; P100 amplitude to fear-neutral face pairs was generally larger in the PTSD group during both the DPA and DPD compared to the DPV ($p < .05$) condition (Figure 16 and 17).

3.3.2 P100 Latency

Planned pairwise comparison of a non-significant condition×face type×facefield× hemisphere×group interaction revealed shorter ($p < .05$) right hemisphere P100 latencies to the right visual field fear-neutral face pairs in the PTSD (M = 106.70 ms, SE ± 3.89) compared to the HC group (M = 117.90 ms, SE ± 3.89) in the DPD condition (Figure 18).

3.3.3 N170 Amplitude

Planned pairwise comparisons of non-significant condition×face type×face field× hemisphere×group interaction were conducted. During the DPV condition, the PTSD group exhibited significantly ($p < .05$) larger left hemisphere N170 amplitudes to right

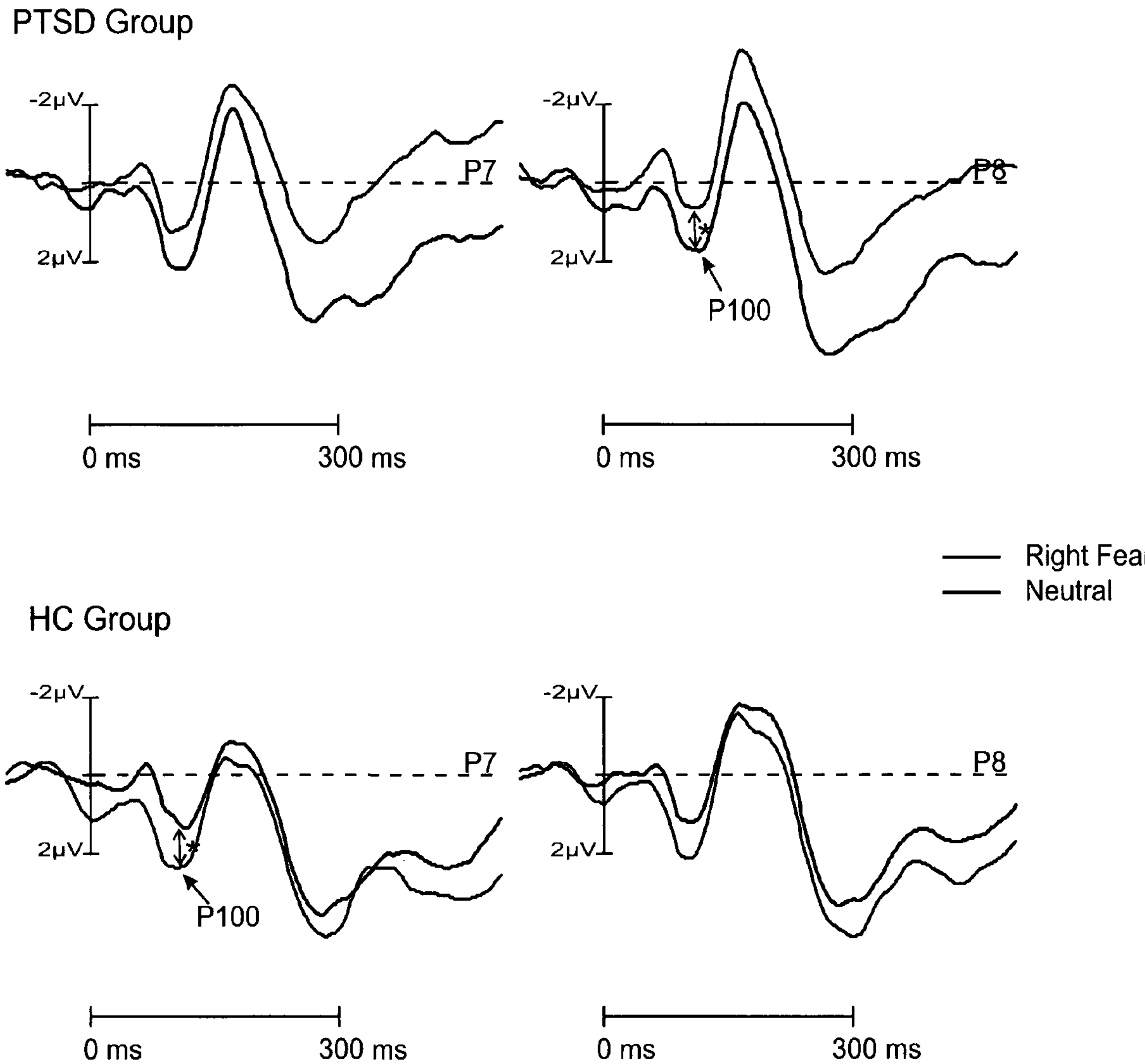


Figure 15. Grand averaged P100 amplitude waveforms to right visual field fear-neutral and neutral-neutral face pairs in PTSD and HC groups during the DPV condition. * $p < .05$

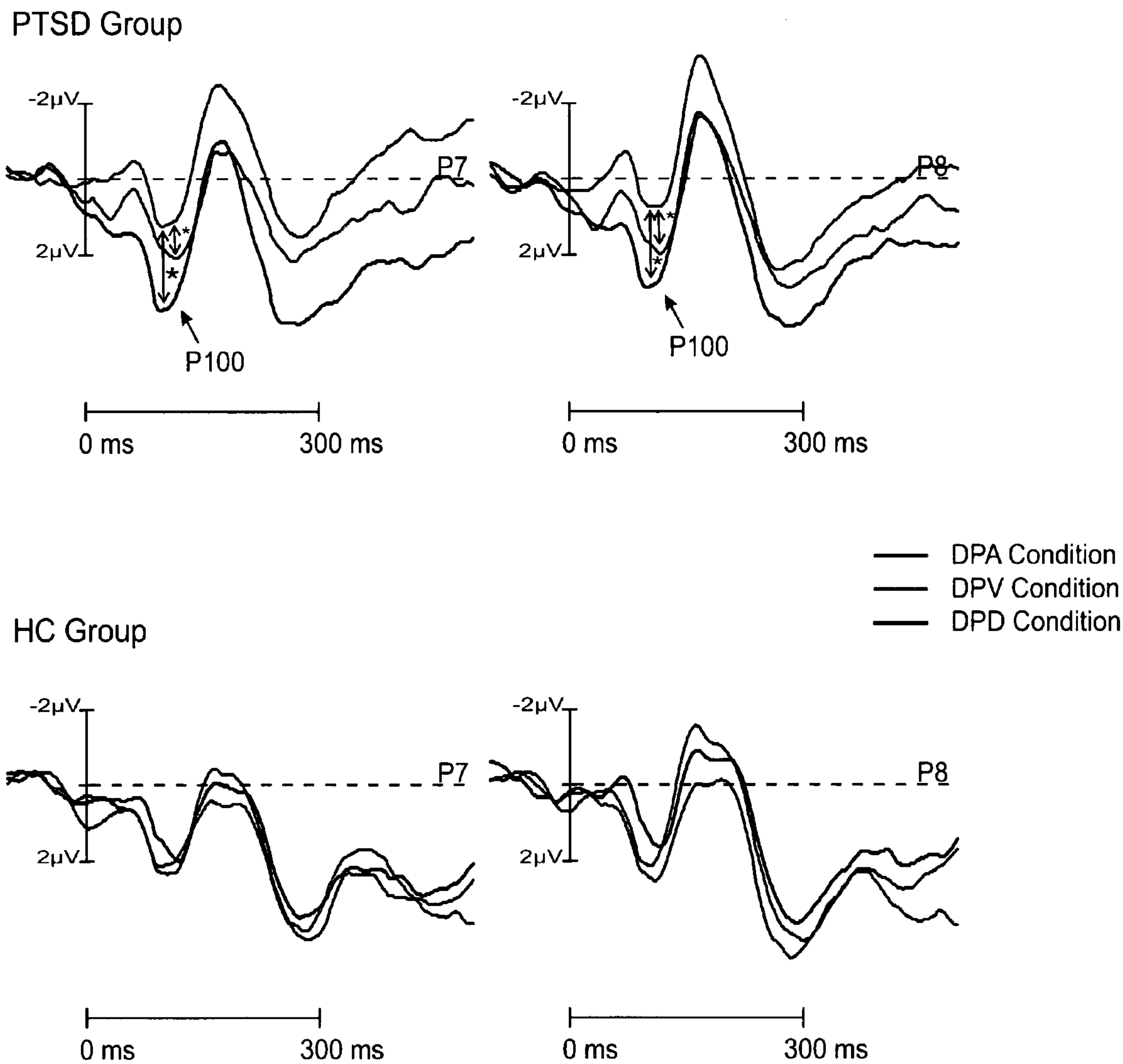


Figure 16. Grand averaged P100 amplitude waveforms to right visual field fear-neutral face pairs in the PTSD and HC groups during DPA, DPV, and DPD conditions. * $p < .05$

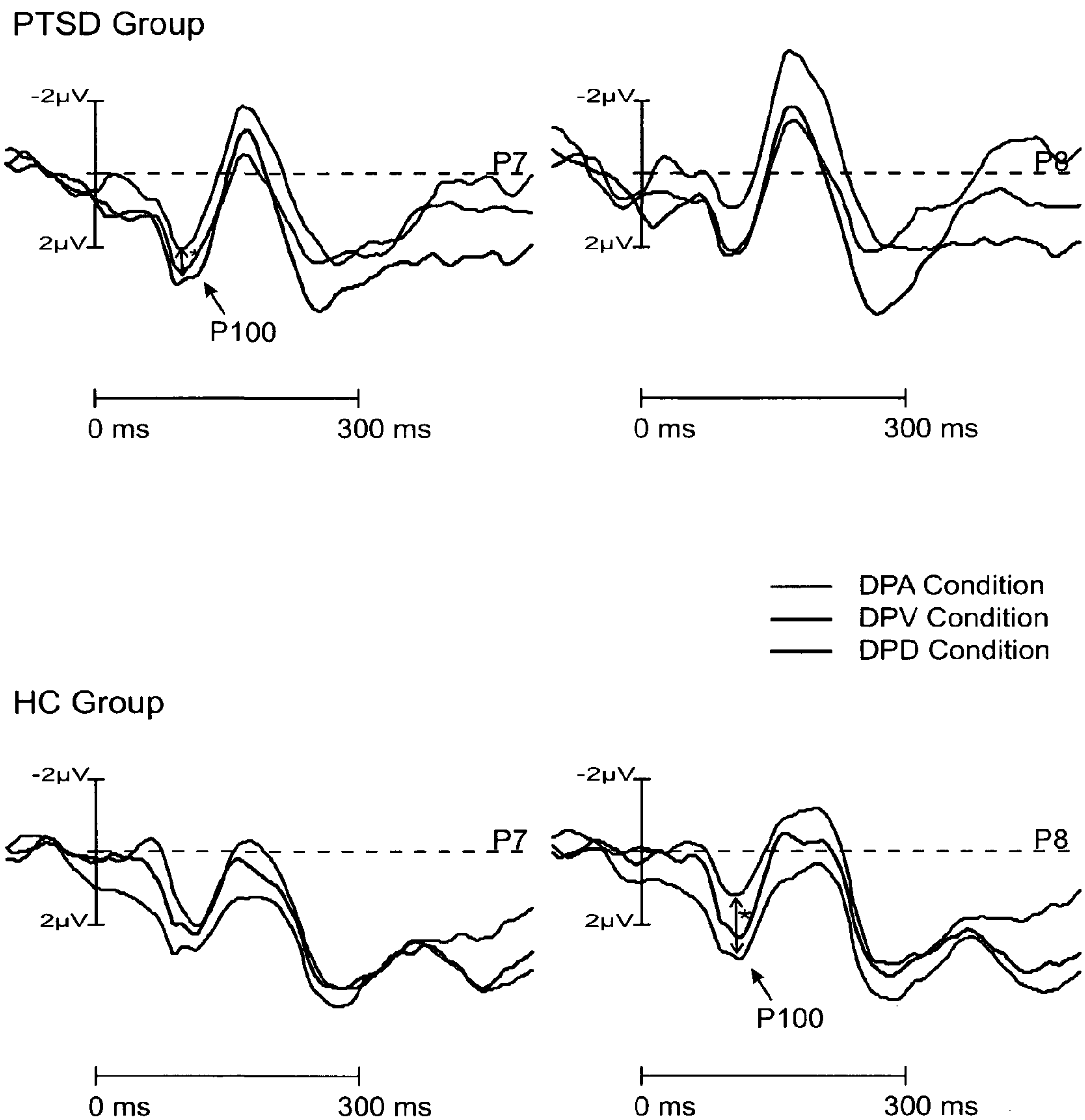


Figure 17. Grand averaged P100 amplitude waveforms to left visual field fear-neutral face pair in the PTSD and HC groups during DPA, DPV and DPD conditions. * $p < .05$

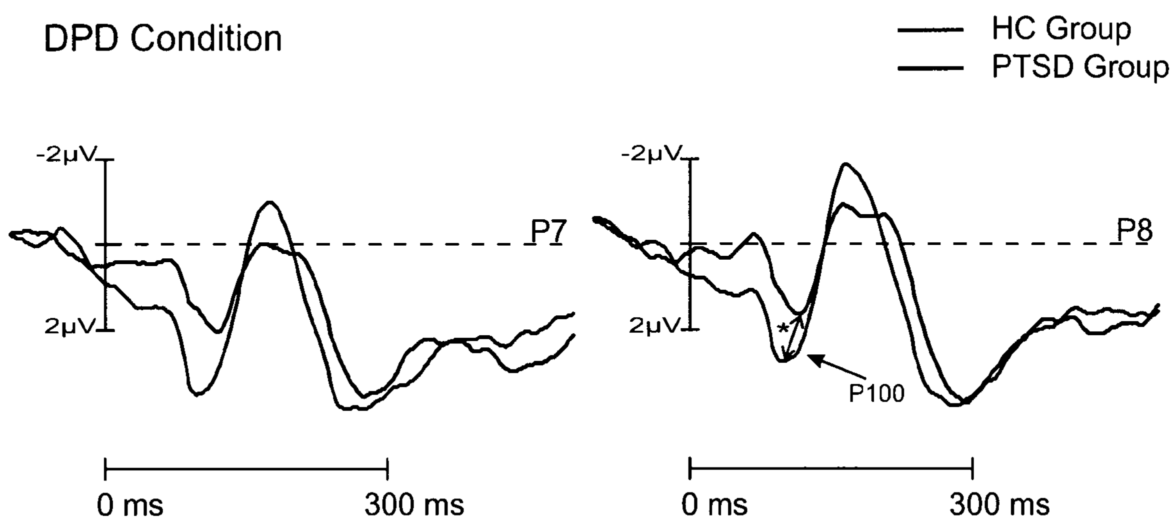


Figure 18. Grand averaged P100 waveforms to right visual field fear-neutral face pairs during the DPD condition. The PTSD, compared to the HC group, exhibited faster latencies to fear-neutral face pairs. * $p < .05$

field fear-neutral face pairs (M = -3.36 μV, SE ± 0.78) compared to neutral-neutral (M = -2.19 μV, SE ± 0.85) face pairs (an expected attentional bias [vigilance] effect). Additionally, during the same condition, this group exhibited a larger ($p < .05$) right hemisphere N170 amplitude to both right visual field angry-neutral (M = -4.51 μV, SE ± 1.09) and right visual field fear-neutral face pairs (M = -4.08 μV, SE ± 0.91) compared to neutral-neutral (M = -2.72 μV, SE ± 1.01) face pairs (an expected attentional bias [vigilance] effect; Figure 19a). No such effects were seen in the HC group (Figure 19b). Larger left hemisphere N170 amplitudes ($p < .05$) to right visual field fear-neutral (M = -3.36 μV, SE ± 0.78) compared to neutral-neutral face pairs (M = -2.19 μV, SE ± 0.85) in the PTSD group during the DPV condition were observed. No face pair effects on N170 amplitude were observed in the HC group. Condition effects were observed such that the DPV condition exhibited larger ($p < .05$) N170 amplitude compared to the DPA condition in the HC group for all three face types. In the PTSD group, both right and left hemispheres N170 amplitude to right and left visual field angry-neutral and fear-neutral face pairs was larger ($p < .05$) during the DPV condition compared to the DPA condition (Figure 20a). No differences in conditions were observed for N170 amplitude to neutral-neutral face pairs (Figure 20b).

Hemisphere differences reflecting larger ($p < .05$) right versus left hemisphere N170 amplitudes were seen in PTSD group across face-pair type and visual field positions. To a limited extent, the same effect was seen in the HC group with right field fear-neutral face pairs in the DPV condition ($p < .05$) and left field anger-neutral face pairs in the DPD condition ($p < .05$).

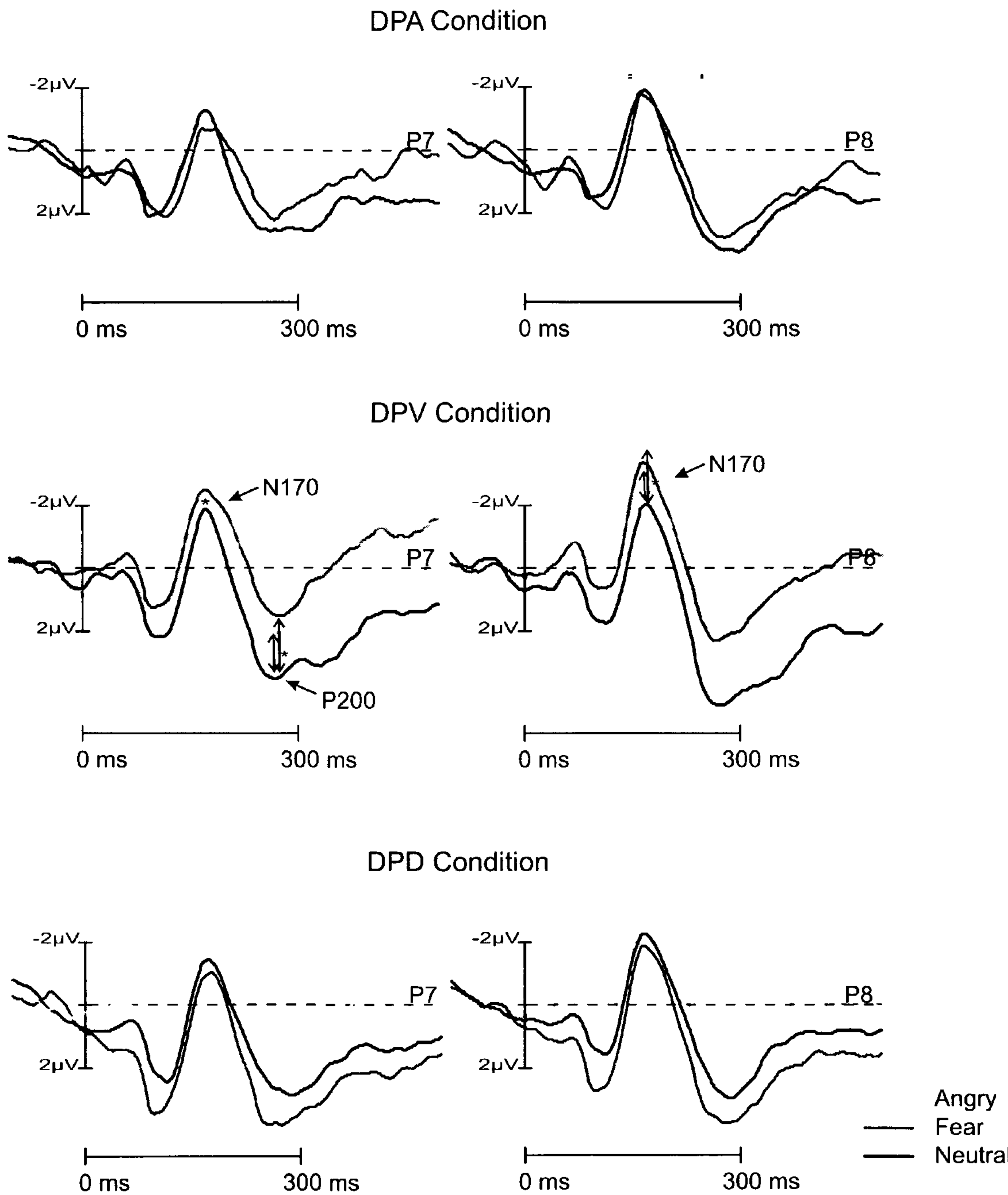


Figure 19a. Grand averaged waveforms showing N170 and P200 amplitudes to angry-neutral, fear-neutral and neutral-neutral face pairs (right visual field) during DPA, DPV, and DPD conditions in the PTSD group. * $p < .05$

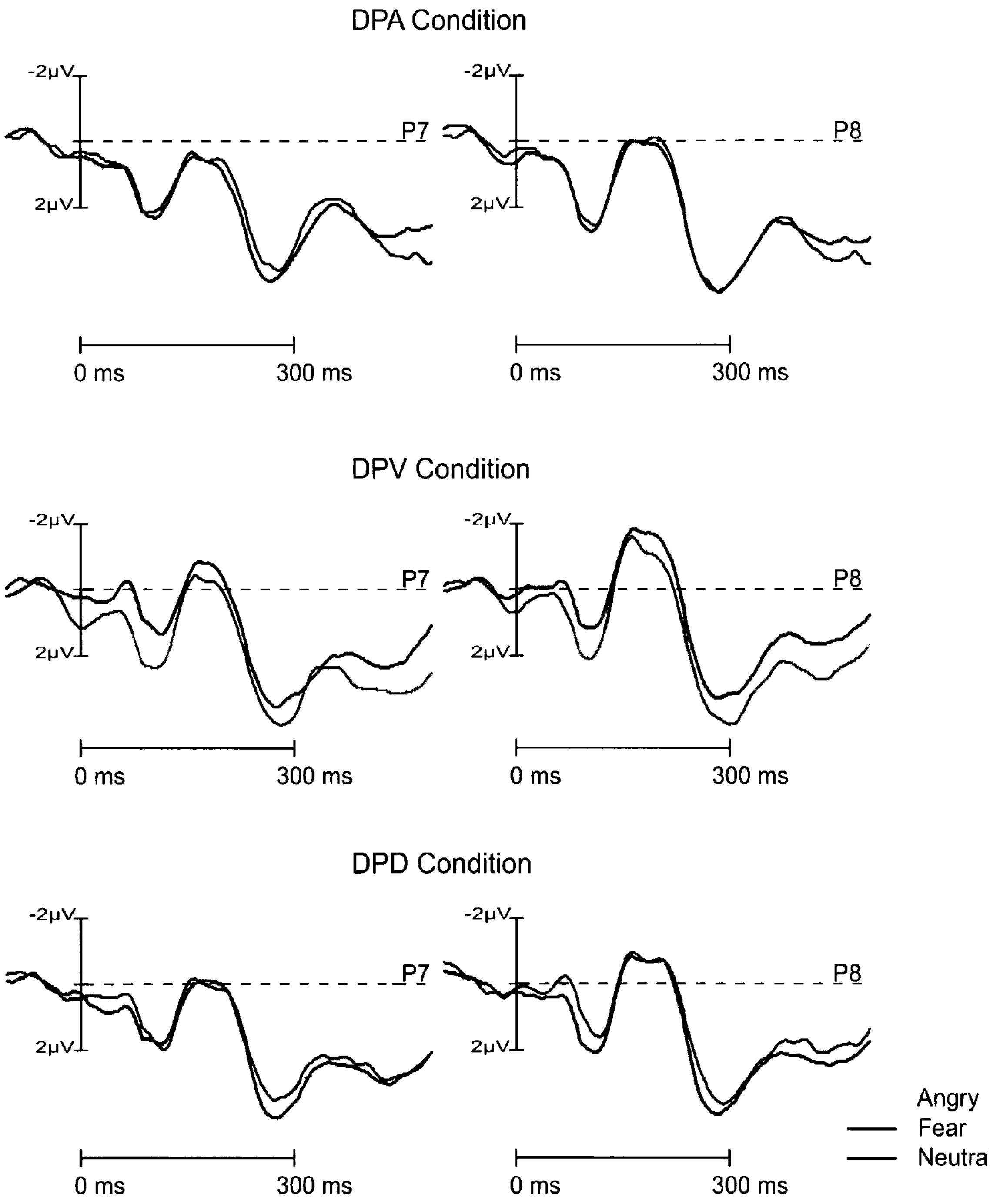


Figure 19b. Grand averaged waveforms showing N170 and P200 amplitude to angry-neutral, fear-neutral and neutral-neutral face pairs (right visual field) during DPA, DPV, and DPD conditions the HC group. * $p < .05$

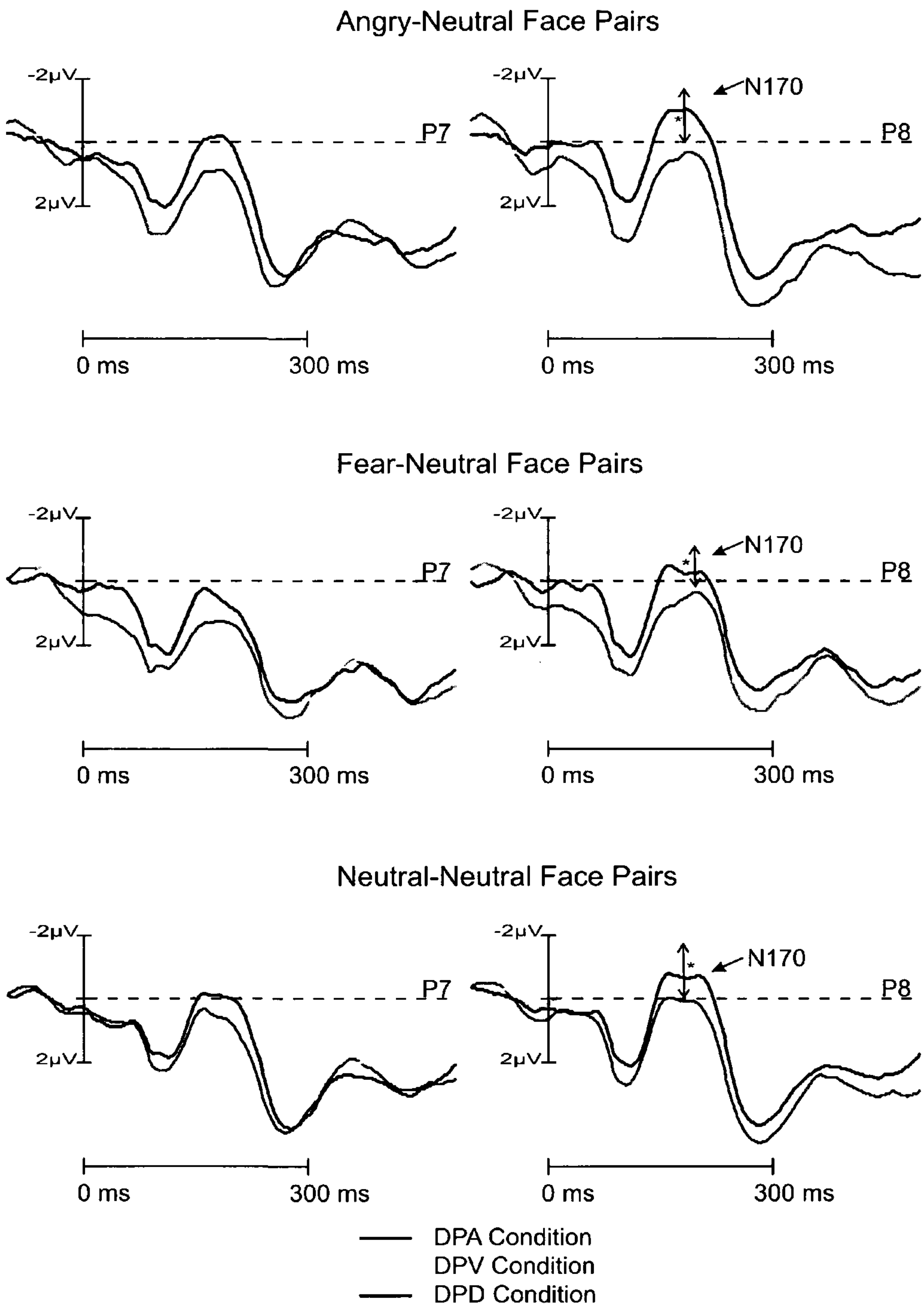


Figure 20a. Grand averaged N170 amplitude waveforms to left visual field angry-neutral face pairs, left field fear-neutral face pairs and neutral-neutral face pairs in the PTSD group during DPA, DPV and DPD conditions. * $p < .05$

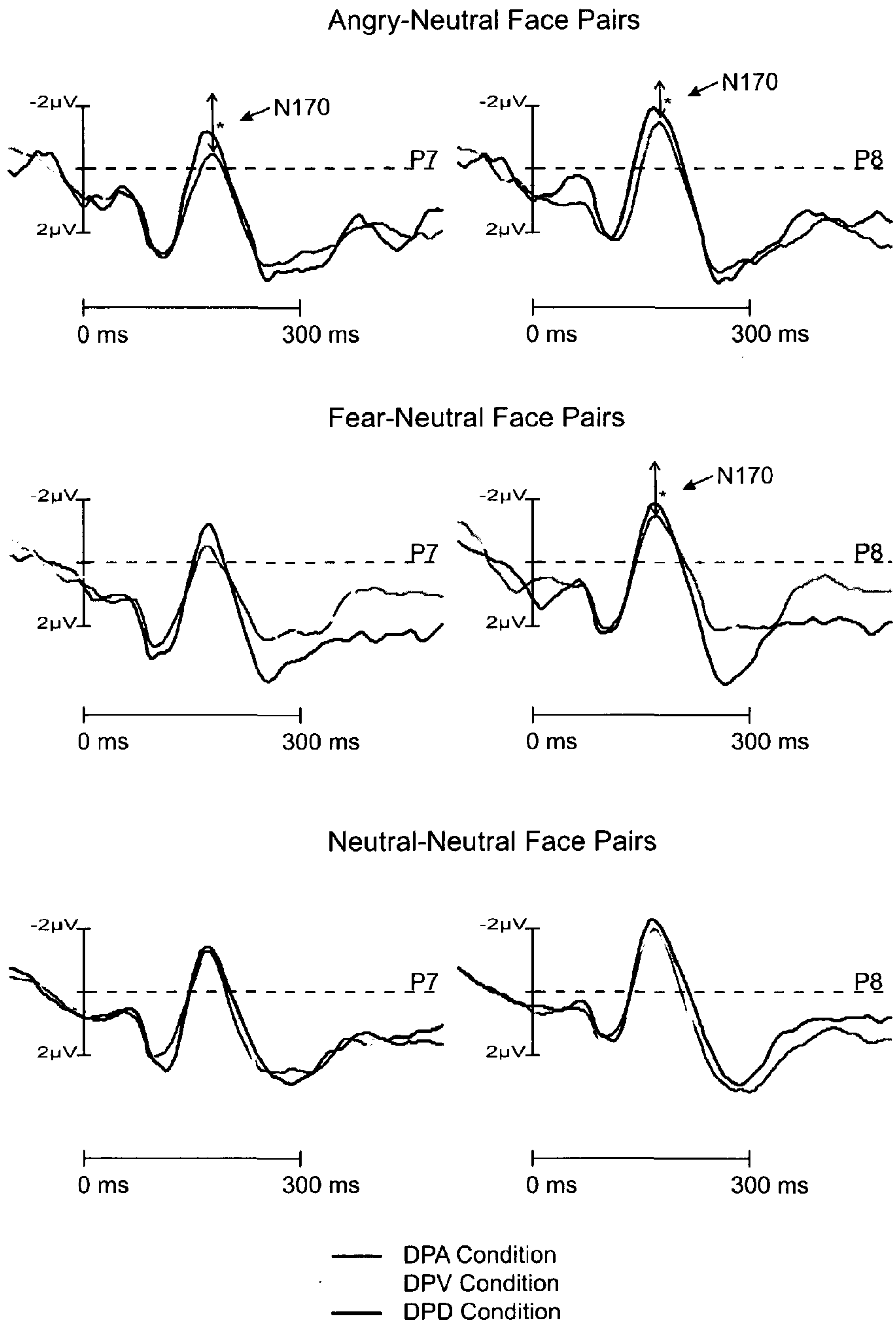


Figure 20b. Grand averaged N170 amplitude waveforms to left visual field angry-neutral face pairs, left visual field fear-neutral face pairs and neutral-neutral face pairs in the HC group during DPA, DPV and DPD conditions. * $p < .05$

3.3.4 N170 Latency

Planned pairwise comparisons of non-significant condition×face type×face field× hemisphere×group interaction were conducted. For the DPV condition, the N170 to right visual field angry-neutral face pairs were shorter ($p < .05$) in the left (M = 172.60 ms, SE ± 4.79) versus right hemisphere (M = 183.40 ms, SE ± 5.52) in PTSD group. Furthermore, for the DPV condition the N170 latency to the right visual field fear-neutral face pair was shorter ($p < .05$) in the right (M = 157.00 ms, SE ± 5.79) compared to the left (M = 185.70 ms, SE ± 5.91) hemisphere for the PTSD group. For the DPV condition, the N170 latency in response to angry-neutral face pairs was shorter ($p < .05$) in the right hemisphere for threat face presentations in the left (M = 173.30 ms, SE ± 5.29) versus right visual field (M = 184.70 ms, SE ± 4.86) in the HC group. For the DPV condition the N170 latency to right visual field angry-neutral face pair was shorter ($p < .05$) in the left (M = 177.50 ms, SE ± 4.79) compared to the right (M = 184.70 ms, SE ± 4.86) hemisphere in the

3.3.5 P200 Amplitude

Planned pairwise comparisons of a non-significant condition×face type×face field× hemisphere×group interaction were conducted. During the DPA condition, left hemisphere P200 amplitudes elicited by left visual field angry-neutral face pairs were greater ($p < .05$) in the HC (M = 5.96 μV, SE ± 0.63) compared to the PTSD group (M = 4.04 μV, SE ± 0.63). Within the PTSD group, the left hemisphere P200 amplitude was larger in the DPV condition ($p < .05$) to neutral-neutral face pairs (M = 4.11 μV, SE ± 0.79) than to right field fear-neutral (M = 2.59 μV, SE ± 0.94) face pairs (an unexpected attentional bias [avoidance] effect; Figure 19a). Similarly, for the DPV condition, right hemisphere P200 amplitude was larger ($p < .05$) in response to neutral-neutral face pairs (M = 4.88 μV, $SE \pm 1.12$) than to right angry-neutral (M = 2.46 μV, $SE \pm 0.94$) face pairs in the PTSD group (an unexpected attentional bias [avoidance] effect). These face pair effects were not observed in the HC group (Figure 19b).

3.3.6 P200 Latency

Planned pairwise comparisons of non-significant condition×face type×face field× hemisphere×group interaction were conducted. During the DPV condition, the PTSD group exhibited a longer ($p < .05$) right hemisphere P200 latency to left visual field fear-neutral face pairs (M = 285.00 ms, $SE \pm 8.09$) compared to neutral-neutral face pairs (M = 274.30 ms, $SE \pm 7.08$) (an unexpected attentional bias [failure in vigilance or disengagement] effect). These P200 latency effects were not observed in the HC group (Figure 21).

3.4. Auditory Oddball Task

3.4.1 Percentage Correct Responses (Hits)

Significant main effects of group (F [1, 38] = 8.05, $p < 0.5$) and condition (F [1, 38) = 23.93, $p < .001$) were observed. The HC group (M = 89.02 %, $SE \pm 2.63$) exhibited a greater percentage of hits than the PTSD group (M = 78.49 %, $SE \pm 2.63$). More hits was also observed for the DPA (M = 90.16 %, $SE \pm 1.67$) compared to the DPD condition (M = 77.36%, $SE \pm 2.74$). Follow-up pairwise comparisons of condition×group interaction (F [1, 38] = 6.23, $p < .05$) revealed a greater ($p < .05$) percentage of hits for

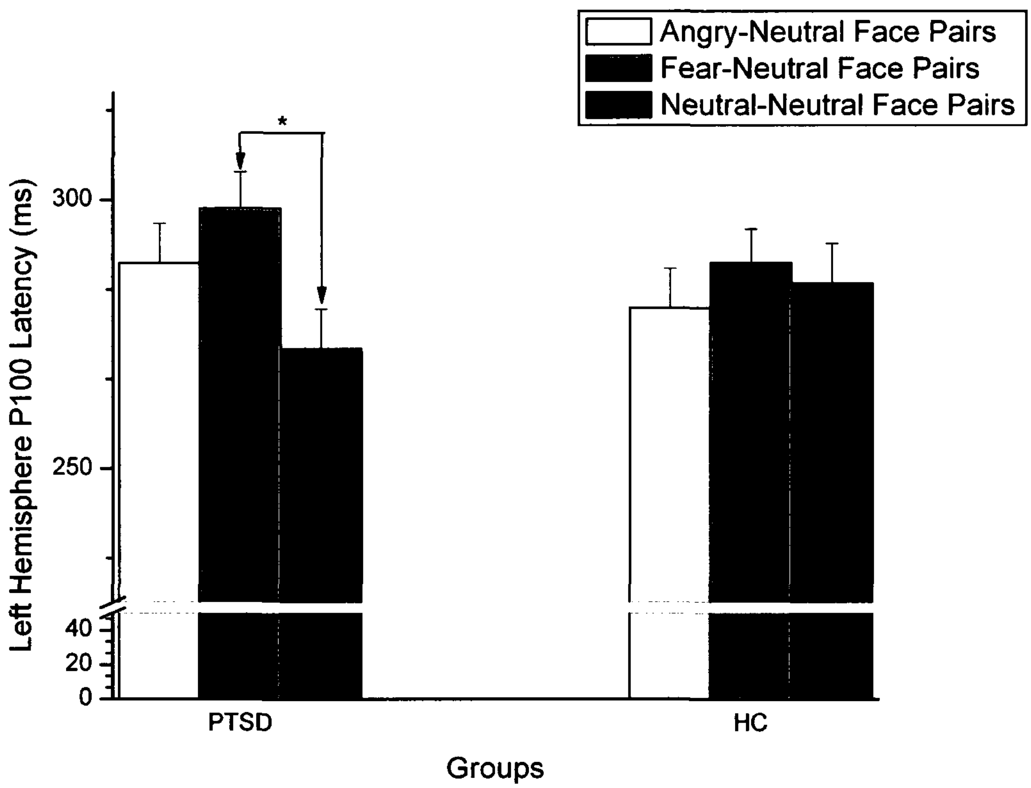


Figure 21. Grand averaged P100 latency to left visual field angry-neutral, fear-neutral and neutral-neutral face pairs in PTSD and HC groups while performing the DPV condition. * $p < .05$

the HC (M = 85.89%, $SE \pm 3.88$) compared to the PTSD group for the DPD condition (M = 68.83%, $SE \pm 3.88$). Additionally, a greater ($p < .05$) percentage of hits was observed for the DPA (M = 88.15%, $SE \pm 3.89$) compared to the DPD (M = 68.83%, $SE \pm 3.88$) condition for the PTSD group (Figure 22).

3.4.2 Percentage False Alarm (FA)

No significant main or interactions effects were observed for deviant tone FAs. Planned comparison of a non-significant condition×group interaction revealed that the PTSD group exhibited a greater ($p < .05$) percentage of FAs (M = 5.74%, $SE \pm 0.91$) compared to the HC group (M = 3.00%, $SE \pm 0.91$) during the DPD condition (Figure 23).

3.4.3 Reaction Time (RT)

Significant main effects of group (F [1, 38] = 4.42, $p < 0.05$) and condition (F [1, 38) = 141.97, $p < .001$) were observed. Shorter RTs to the deviant tone were exhibited by the HC (M = 661.41 ms, $SE \pm 30.02$) compared to the PTSD group (M = 752.64 ms, $SE \pm 30.02$). Shorter RTs during the DPA (M = 560.64 ms, $SE \pm 18.94$) compared to DPD condition (M = 853.41 ms, $SE \pm 29.06$) were also observed. (Figure 24)

Planned pairwise comparison of a non-significant condition×group interaction revealed shorter ($p < .05$) RTs for the HC group (M = 517.22 ms, $SE \pm 26.78$) compared to the PTSD group (M = 604.06 ms, $SE \pm 26.78$) for the DPA condition. Additionally, both the HC and PTSD groups exhibited a shorter RT ($p < .05$) for the DPA versus the

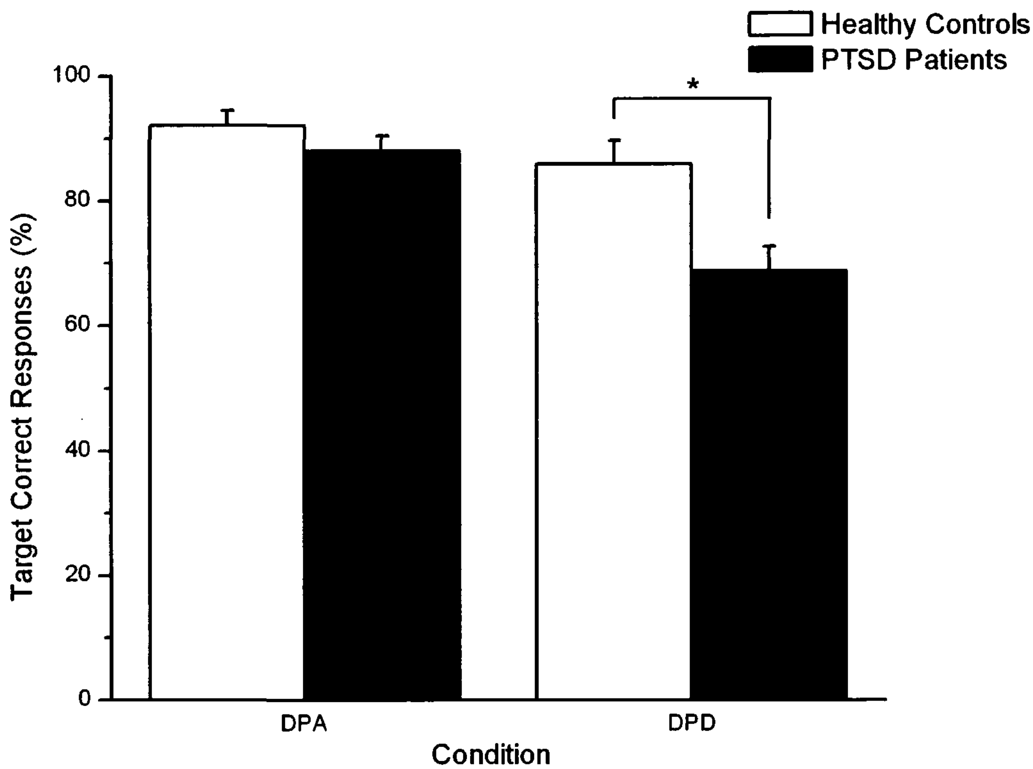


Figure 22. Mean (±*SE*) percentage deviant (tone) target correct responses in PTSD and HC groups during the DPA and DPD conditions. * $p < .05$

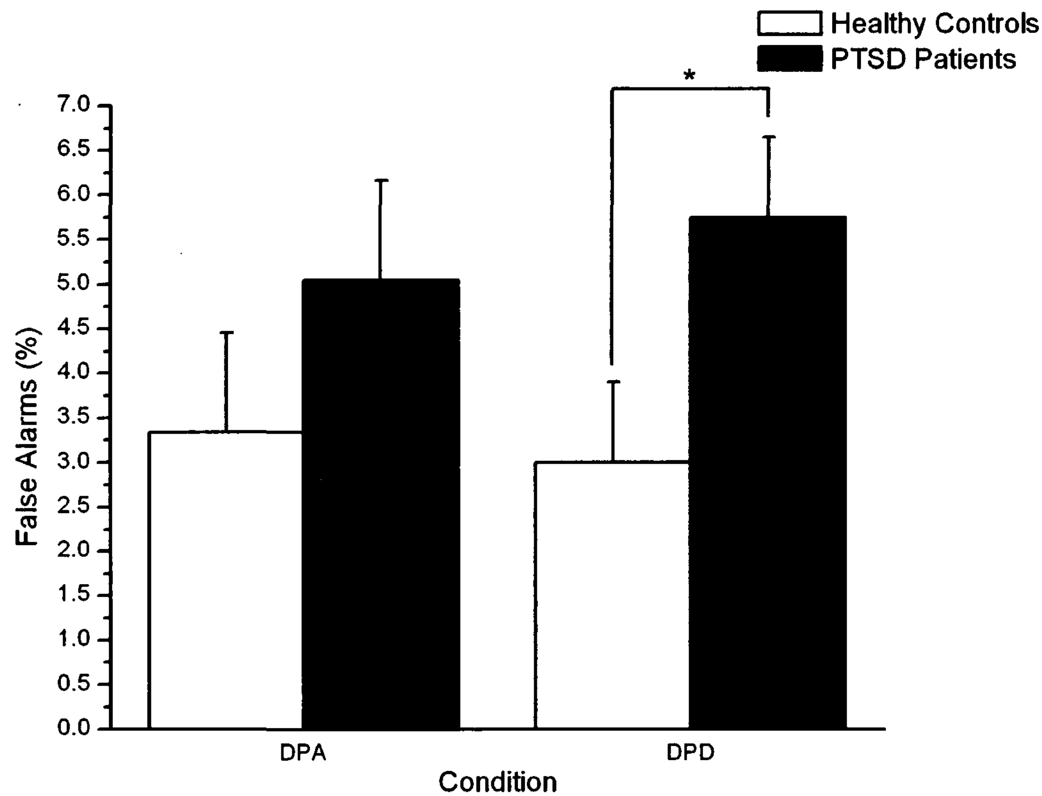


Figure 23. Mean (±*SE*) percentage false alarms to non-deviant (tone) responses in PTSD and HC groups during the DPA and DPD conditions. * $p < .05$

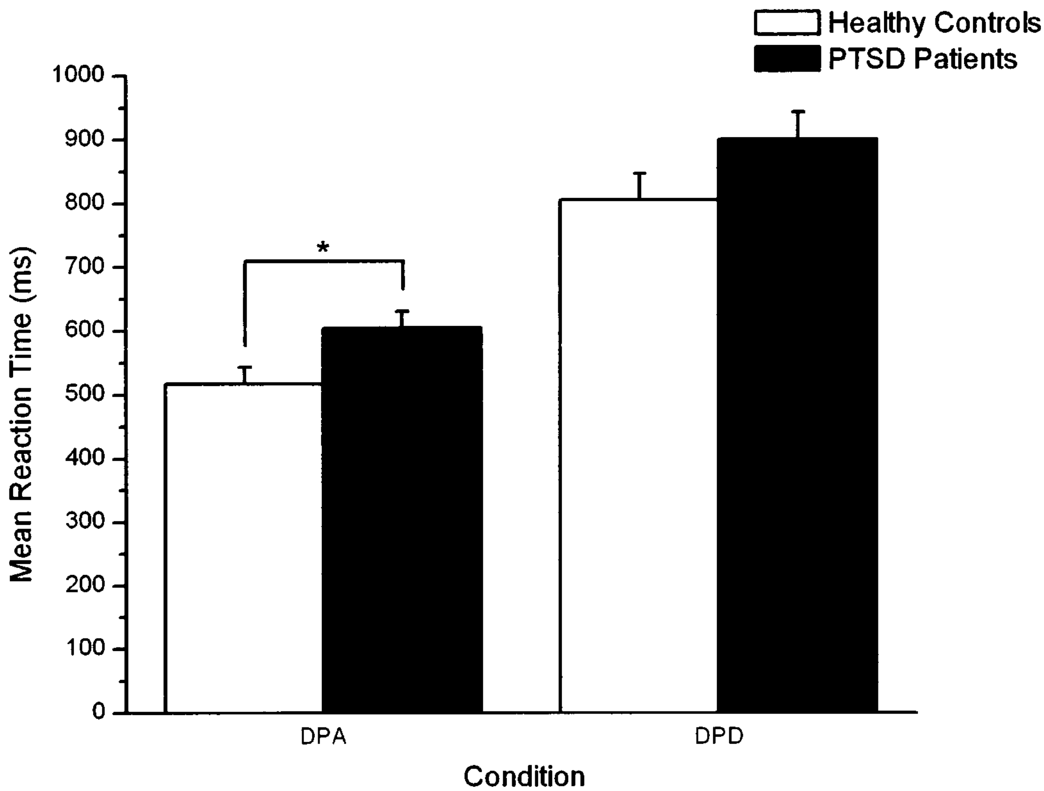


Figure 24. Mean (±*SE*) deviant (tone) target reaction time in PTSD and HC groups during the DPA and DPD conditions. * $p < .05$

DPD condition (HC: M = 805.61 ms, $SE \pm 41.10$; PTSD: M = 901.22 ms, $SE \pm 41.10$). (Figure 24)

3.4.4 Deviant P300 Amplitude

A main effect of condition was observed (F [1, 37) = 17.26), in which a larger P300 amplitude to the deviant tone was observed during the DPA (M = 11.59 μV, $SE \pm$ 1.05) compared to the DPD condition (M = 10.82 μV, $SE \pm 1.08$). No further effects for the P300 amplitude were observed with planned pairwise comparisons. (Figure 25)

3.4.5 Deviant P300 Latency

No significant main or interaction effects were observed for P300 latency. No effects were observed with planned pairwise comparisons involving P300 latency.

3.5. Subjective Ratings

3.5.1 State Anxiety

A significant group effect (F [1, 38] = 6.68) was observed in which the HC group (M = 46.22, $SE \pm 1.25$) exhibited greater state anxiety compared to the PTSD group (M = 41.63, $SE \pm 1.25$).

3.5.2 Facial Valence

A significant main effect of face (F [2, 76] = 20.60, $p < .001$) was observed; neutral faces (M = 5.64, $SE \pm 0.17$) were rated to be more pleasant than angry (M = 3.73, $SE \pm 0.31$) and fearful faces (M = 3.93, $SE \pm 0.35$).

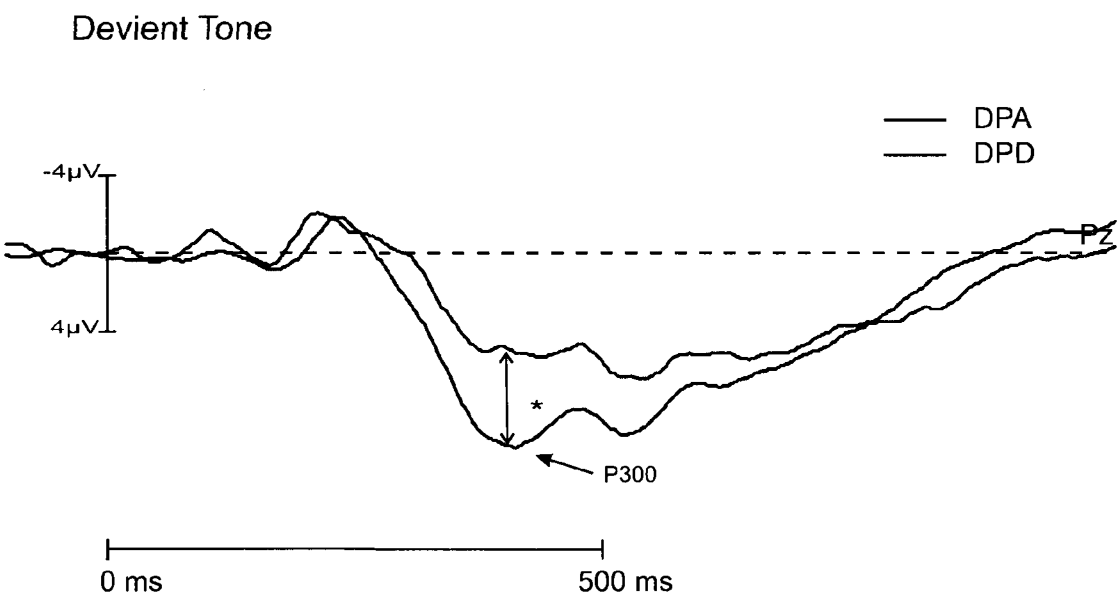


Figure 25. Grand averaged P300 amplitude waveform to deviant tones during DPA and DPD conditions, collapsed across groups. * $p < .05$

3.5.3 Facial Arousal

A significant main effect of face F (2, 76) = 45.61, $p < .001$) was observed with angry ($M = 6.51$, $SE \pm 0.31$) and fearful faces ($M = 6.53$, $SE \pm 0.33$) being more arousing than neutral faces ($M = 3.64$, $SE \pm 0.29$).

4. Discussion

The aim of the present study was to investigate the behavioral and neural correlates of attentional biases in PTSD. More specifically, this study examined brain mechanisms underlying involuntary orienting using a version of the dot-probe task involving threat faces (specifically, fearful and angry faces) in patients with PTSD and matched controls. Furthermore, the investigation aimed to assess the influence of task distraction on attentional biases. Relative to the initial hypothesis, and consistent with previous research using the dot-probe task, attentional biases to threat face pairs relative to neutral face pairs, were shown in healthy controls, in the form of a vigilance effect, as well as in PTSD patients, in the form of vigilance, avoidance and disengagement effects. Condition effects also were found whereby the presence of a response to an auditory stimulus during the dot probe task (i.e., dot probe auditory [DPA] or dot probe dual attend [DPD] conditions) influenced attentional biases but primarily in the PTSD group (Table 2).

The key to demonstrating attentional bias and their moderation by distraction is the need to show valid methodologies that: a) resulted in differential responsiveness to the facial valence (threat vs. neutral) stimuli and b) the utilization of additional resources with the DPA and/or DPD condition(s) relative to the DPV condition. The threat faces elicited subjectively different ratings on valence and arousal dimensions, which distinguished the threat faces from neutral faces. Additionally, at the neural level ERPs also reflected differential processing of neutral versus angry and fearful face pairs; this was consistently observed with the face-specific N170. The N170 amplitude exhibited

Table 2. Summary of study findings classified into components of attentional bias (vigilance, difficulty disengaging and avoidance effects) for PTSD and HC groups during the DPA, DPV, and DPD conditions.

Response	**DPV**	**DPA**	**DPD**
Probe Hits			PTSD: Attentional bias to angry-neutral and fear-neutral face pairs (*vigilance effect*).
Probe Incorrect Response	HC: Attentional bias to angry-neutral face pairs (*vigilance effect*).		
Probe RT	PTSD: Attentional bias to fear-neutral face pairs (**avoidance effect**).		PTSD: Attentional bias to fear-neutral face pairs (**avoidance effect**).
Probe P300 Amplitude	PTSD: Attentional bias to fear-neutral face pairs (**avoidance effect**) and to angry-neutral face pairs (**disengagement &** *vigilance effects*).		PTSD: Attentional bias to angry-neutral face pairs (**avoidance effect**).
Probe P300 Latency	PTSD: Attentional bias to fear-neutral face pairs (vigilance effect).		PTSD: Attentional bias to fear-neutral face pairs (**avoidance**) and to angry-neutral face pairs (*vigilance effect*).
Face P100 Amplitude	PTSD: Attentional bias to fear-neutral face pairs (**avoidance effect**). HC: Attentional bias to fear-neutral face pairs (*vigilance effect*).	PTSD: Attentional bias to angry-neutral face pairs (*vigilance effect*). HC: Attentional bias to angry-neutral face pairs (*vigilance effect*).	
Face P100 Latency			
Face N170 Amplitude	PTSD: Attentional bias to fear-neutral and angry-neutral face pairs (*vigilance effect*).		
Face N170 Latency			
Face P200 Amplitude	PTSD: Attentional bias to fear-neutral face pairs and angry-neutral face pairs (**avoidance effect**).		
Face P200 Latency	PTSD: Attentional bias to fear-neutral face pairs (**failure to vigilance or disengagement effect**).		

larger amplitudes to fear-neutral and angry-neutral face pairs versus neutral-neutral. When evaluating the impact of the auditory distracter, clear overall behavioral effects were observed with dot-probe reaction time (RT) evidenced by a slowing in RT in the DPD versus the DPV conditions. Attentional allocation to the dot-probe target processing as evidenced by the visual P300 amplitude was also affected by the distraction manipulation, with smaller P300 amplitudes seen in the DPD versus the DPV condition. The addition of the auditory distraction combined with the visual dot-probe appeared to usurp additional resources as evidenced by slower RT responses in the DPD compared to the DPA condition and by smaller auditory P300 amplitudes in the same conditions.

With respect to group differences, healthy controls (HC compared to PTSD patients) appeared, in general, to exhibit greater performance abilities regardless of face stimulus valence or task condition. This was shown both by faster RTs in the dot-probe and auditory oddball tasks and also by larger P300 amplitudes in the dot-probe task. These differences may reflect resource capacity differences between patients and HCs, but may also be affected by medication and/or concomitant comorbid disorders (i.e., ADHD, depression) in the PTSD group that may impact on cognitive abilities. An education difference was also observed, where HCs reported having more schooling compared to the PTSD patients. The difference in education may have effected the way in which the patients processed the auditory distraction tones, resulting in patients performing poorer during the DPA and DPD conditions compared with the HC. Additionally, differential processing of the auditory distraction by the PTSD patients may have influenced the sensory processing of the facial stimuli. Within the HC group, during the DPV condition, attentional bias effects were limited and were seen at the behavioural level (% incorrect responses) with response only to angry-neutral face pairs. At the electrophysiological level, attentional bias effects were observed by ERPs to fear-neutral face pairs (larger P300 amplitudes to fear-neutral face pairs). Both of these measures of bias indicated increased vigilance to these threat stimuli (facilitated orientation and/or engagement). These vigilance effects where shown to be eliminated with DPA and DPD conditions. In the case of fear-neutral face pairs there was also evidence that the DPD condition specifically delayed the speed by which fear-neutral face pairs were processed, as indexed by longer P100 latencies in HC compared to PTSD participants. With respect to anger-neutral face pair stimuli, although DPA diminished bias at the behavioural level, persistent bias effects to anger-neutral face pair stimuli were still seen at early stages of processing, as evidenced by the visual facial ERPs findings. Specifically, P100 amplitudes were larger to angry-neutral versus neutral-neutral face pairs. Furthermore, both the P100 and P200 amplitudes were larger to anger-neutral face pairs in the HC group. One might conclude that in HCs, DPA and DPD conditions antagonized post-perceptual processes related to anger-neutral face pair stimuli, but had the effect of augmenting aspects of early preconscious processing of angry-neutral face pairs. These early P100 related findings are consistent with the general ERP literature showing top-down influences of attentional processes on early sensory functions emanating from the extrastriatal cortex (Luck & Hillyard, 2007). These effects were not associated with a specific stimulus field or hemisphere, a result which is more or less in agreement with studies reporting right and left hemisphere activation to threat stimuli in anxious individuals (Esslen et al. 2000; Haxby et al., 2004; Mogg & Bradley, 1999).

As with previous studies that have observed more evidence of preferential attending to threat-related stimuli in anxious individuals, the current study found converging lines of evidence supporting more consistent and multifaceted attentional bias effects to such stimuli in PTSD patients. In PTSD patients performance of the visual dot-probe task alone elicited an attentional bias predominantly toward to fear-neutral face pair stimuli. Attentional biases to fear-neutral face pairs appeared in the form of vigilance, as seen electrophysiologically by enhanced face-specific N170 amplitudes and in the faster probe P300 latency. This attentional bias also appeared in the form of avoidance as indexed by P100 and P200 amplitudes to fearful faces, and P300 amplitude probes to fearful faces and at the behavioural level with reaction times (slower RT to threat stimuli). Although the bias was overwhelmingly fear specific, the avoidance and vigilance effects did not present in the expected tèmporal pattern (i.e., vigilance preceding avoidance). This can somewhat be accounted for by more recent theories of attentional bias in anxiety disorders which, although relating facilitated attention to an automatic threat detection mechanism linked with the amygdala, and attentional avoidance (and disengagement failure) to strategic cognitive processes linked with higher order cortical structures, have suggested that temporal boundaries between these systems are unclear, overlapping, dynamic and interactive (Cisler & Kosler, 2010). A mixed biased profile was also observed with angry-neutral face pair stimuli whereby the direct processing of angry-neutral face pairs (indexed by visual ERPs) was initially manifested as an automatic avoidance and vigilance processes, while processing of the probes replacing angry-neutral face pair reflected both engagement and failure to disengage. Impaired disengagement has been interpreted as a joint product of: a) enhanced engagement responses elicited in the automatic system and b) ineffective avoidance response generated in the strategic system. This can be related to a conflict between an impulsive tendency to orient/attend to a threat-related stimulus and a behavioural process to attend away from the stimulus (Ouimet, Gawronski & Dozois, 2009).

Performance in the DPA condition resulted in four instances of a clearly diminished bias to threat face pairs (i.e., attentional bias observed in DPV but not in DPA) in the PTSD group. This diminished bias in the auditory attend condition was observed by the absence of P100 (fear-neutral face pairs), N170 (fear-neutral and anger-neutral) amplitude responsively to threat faces, and P200 (fear-neutral and angry-neutral) amplitude and latency to threat faces. In another instance the direct processing of threat faces during the DPA (versus DPV) condition were shifted, with an additional bias emerging as seen by enhanced P100 (vigilance) to anger-neutral face pairs.

Performance in the DPD appeared to result in unique alterations in attentional bias. With respect to the direct processing of threat stimuli as evidenced with visual ERPs, the DPD condition exerted attenuating effects on attentional bias to threatening stimuli as reflected by the diminished amplitude of the face-specific N170 (vigilance to fear-neutral and angry-neutral face pairs). Addition, this attenuated attentional bias was demonstrated by diminished P100 amplitude (vigilance to angry-neutral face pairs) as well as P200 amplitude/latency (vigilance and failure to vigilance or disengagement, respectively) indicators of attentional bias. The processing of dot-probe targets replacing fear-neutral face pairs (avoidance effect) was diminished in the DPD versus DPV condition, as indexed by reduced P300 amplitudes. The DPD condition also shifted the biasing style, acting to change vigilance to fear-neutral face pairs to avoidance as shown with P300 amplitude and latencies to probes replacing threat faces. New biases were also brought into play with the DPD condition, including the vigilance effects for appearance of anger-neutral (as seen by % hits and P300 latency) and fear-neutral face pairs (seen by % hits).

Together these findings offer mixed support for the study hypothesis of a reduced attentional bias in the presence of a distracter. Although our hypothesis was fueled by assumptions that attentional resources in general would be diverted away from the processing of threat with the addition of a task-component (the effects being quantitatively greater with DPD versus DPV), Lavie's (2005) load theory proposes two means by which control of selective attention can prevent the processing of irrelevant and potentially distracting stimuli. The first is a passive means of control, which suggests that when task-relevant processing involves a sufficiently high perceptual load that exhausts available capacity, task-irrelevant stimuli are not perceived. The second means of control refers to an active means of executive control, which suggests that active maintenance of stimulus-processing priorities minimizes distraction by low-priority task-irrelevant stimuli. Therefore, Lavie's theory predicts that when executive control is loaded, the task-irrelevant distracter should exert greater interference (Lavie, 2005).

Lavie (2008) has reported on the distracter augmenting effects of cognitive load in multiple conditions, including testing the effects of two-task coordination on distractibility with tasks. The ability of cognitive load to exacerbate distraction has been hypothesized to result from the need to coordinate two different (with different task rules) tasks and the resulting reduction in the executive to provide goal directed attention control (of the processing in each task). Hence, greater interference by goal-irrelevant distracters follows (Lavie, 2008).

Tone discrimination in the DPA task can essentially be regarded as a perceptual process. Recent research has indicated that distracter perception can be prevented when processing of task-relevant stimuli involves high perceptual load (Lavie, 1995; 2005). These general findings have been extended to emotional distracters with fMRI indexed processing of emotional face expressions in the amygdala being substantially reduced and/or eliminated with high perceptual load (Vuilleumier et al., 2001, Pessoa et al., 2002). As previously discussed, given the generally reduced cognitive abilities of the patient population, the DPA condition may be experienced as a perceptually-loaded task in the PTSD group. Although studies on cross model effects of perceptual load have been mixed, fMRI studies have indicated that auditory load exerts effects on the perception of visual distracters (Bermain & Colby, 2002). In the PTSD group, the attentional bias to fear-neutral face pair stimuli (avoidance and vigilance) was exhibited with the P100, and P200 amplitude and face-specific N170 amplitude, shown in the DPV condition, but not evident in the DPA condition. These findings suggest a reduction of the intrusions of emotional distracters. The emergence of new bias with DPA condition was seen with angry-neutral face pairs and thus may reflect the differential effects of perceptual load on the neural underpinnings of angry faces.

In partial support of Lavie's (2008) load theory was the finding that three additional bias effects were seen in the DPD condition but not in the DPA and DPV conditions (vigilance for angry-neutral face pair [increased % hits; decreased P300 latency] and vigilance for fear-neutral face pair [increased % hits]). These results suggest that task coordination involving different sensory modalities may be unduly taxing on executive control and hence may result in PTSD patients being more prone to distraction. Other markers of attentional bias seen in DPV were either resistant (RT to probes replacing fear-neutral face pairs [avoidance]) to the effects of DPD, were diminished (reduced probe P300 amplitude to fear-neutral face pairs [avoidance]) by DPD or replaced by alternative (probe P300 amplitude to angry-neutral face pairs [disengagement & vigilance to avoidance]) biases. These behavioural and electrophysiological markers, although not exhibiting any consistent pattern or relationship to any one specific emotional valence, more then likely reflect moderation by different processes and neural structures, each with varying sensitivity to the effects of executive control.

What was sticking and unexpected in the DPD (vs. DPA and DPV) condition was the complete absence of visual (P100, N170, P200) ERP indicators of facial emotional processing in spite of the presence of the behavioral and electrophysiological (P300) evidence of attentional bias (in the dot probe task) in the same condition. Although this suggests that dual-task performance may dramatically diminish sensory processing of facial emotional faces, it is possible that these threat stimuli may have also activated associative systems causing threat related associations to impact on dot-probe task performance. In recent multi-process models of cognitive vulnerability to anxiety, associative systems are considered to consist of reflexive processes, which are automatically activated in response to threat related stimuli and, via spreading activation, result in the appearance of fear-related mental representations on the basis of similarity and temporal contiguity (Ouimet et al., 2009). Individual differences in frontal executive function have been shown to moderate the associative system with individuals with low capacity (such as seen in anxiety disorders) showing strong influences of associative rather than rational rule-based processes (Hofman, Gschwendner, Friesc, Wiers, & Schmett, 2008).

4.1 Limitation

Limitations of this study should be acknowledged. The samples were relatively small and patients were of mixed anxiety etiology. The patient group was also receiving medication, which may have moderated anxiety and cognition and in addition, they had concurrent disorders (i.e. ADHD, depression) that may have altered the appearance and intensity of attentional bias (Musa et al., 2003). At the design level, several conditions were lacking in the study that may have contributed to better understanding of attentional bias in anxiety. These include dot probe task without auditory stimulus and auditory task alone. No one task methodology is though to be able to capture all components of attentional bias and future studies may wish to adopt two or more conventional tasks to broaden our understanding of these components the conditions under which they may emerge.

4.2 Implications

The study effects are small and varied and therefore one might question their clinical relevance. However, it should be kept in mind that the patient's prioritization of the dot-probe task may have diminished bias in relation to the extent that may be seen in response to real-life threat stimuli that often require action. Thus, exposure to real-life threat stimuli may pose stronger influences on attentional engagement and disengagement. Research has suggested that the effectiveness of executive control over unwanted anxiety responses can be enhanced with cognitive-behavioural treatment (CBT; Shermal et al., 2008). The general observation of apparent reduced cognitive abilities in PTSD has an impact on attentional bias and thus clinical intervention therapies tailored towards practicing executive control processes using CBT may help reduce these biases. Further, the implementation of attentional training protocols that are individual-specific, targeted to specific biases, and specific parameters (distraction and no distraction), may compliment and augment executive control improvements seen with CBT (Ouimet et al., 2009).

4.3 Summary

To the author's knowledge, this is the first study in PTSD to combine electrophysiological and behavioural probes in the study of attentional bias to facial threat stimuli. Attentional vigilance, disengagement and avoidance deficits were observed and depending on distracter conditions, their involvement in the processing of facial threat and threat-associated target probes were differentially impacted.

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6. APPENDICES

6.1 APPENDIX A: SAMPLE SIZE POWER ANALYSIS

F tests – ANOVA: Repeated measures, within-between interaction

Analysis: A priori: Compute required sample size

Input:	Effect size f	= 0.25
	α err prob	= 0.05
	Power (1−β err prob)	= 0.95
	Number of groups	= 2
	Repetitions	= 3
	Corr among rep measures	= 0.5
	Nonsphericity correction ε	= 1
Output:	Noncentrality parameter λ	= 16.500000
	Critical F	= 3.105157
	Numerator df	= 2.000000
	Denominator df	= 84.000000
	Total sample size	= 44
	Actual power	= 0.955733

6.2 APPENDIX B: PATIENT CONSENT FORM

University of Ottawa
Institute of Mental Health Research

Services de santé
Royal Ottawa
Health Care Group

INFORMATION SHEET (Patient Version)

Title of Proposal: An Electrophysiological Investigation of Attentional Bias and Divided Attention in a Forensic Posttraumatic Stress Disorder (PTSD) Population.

Principal Investigators: Dhrasti Shah, M.A. (cand.), Verner Knott, D.Phil., C.Psych.

INTRODUCTION

Please take time to read carefully and think about the information before you give your consent to be a research volunteer in this study. This information describes the purpose and procedures. It also explains the possible risks and benefits of the proposed research. Feel free to discuss any questions with the study investigators. You will receive a copy of this information sheet if you consent to participate. This study will be conducted in English only.

BACKGROUND

People with PTSD quickly focus their attention to fearful information. The specific brain processes that cause this in PTSD are not known. Distraction by pleasant information may reduce attention to fearful events. Brain processing of fearful events is needed to understand how PTSD patients process this information with and without a distraction. This understanding may help find other treatments for this disorder.

PURPOSE

This study wants to understand how the brain responds to threatening facial pictures. The aim is to understand the difference between brain responses with and without distraction. This will involve measuring brain electrical activity from the surface of the scalp. This provides us with a harmless way of measuring brain activity while looking at threatening and non-threatening facial pairs. There are two aims of this study. (1) Compare the brain activity of PTSD volunteers with controls in response to fearful facial expressions (e.g. fear, anger) versus non-fearful facial expressions. (2) Compare brain activity during distraction and no-distraction. The study will also use self-report questionnaires to review the participants feeling of the facial expressions.

PROCEDURES

Before the test session in the laboratory, you will be interviewed by a study investigator. You will be asked questions about your mental and physical health. This will take approximately 30 minutes. You will participate in one, 2.5-hour test session. You will be asked to not use alcohol, street drugs, nicotine, or caffeine beginning at maximum 24 hours before the test session. During test session, sensors will be placed on your scalp and around your eyes. This will monitor electrical activity of the brain. Once the sensors are in place, you will finish under three different conditions. In one condition you will be asked to press the response key when a bar is presented on the screen. While you are carrying out this task facial expressions will appear on the screen (e.g. angry, fearful) and you will hear sounds through head phones. In another condition you will be asked to ignore the bar and respond to the sounds. In third condition you will be asked to respond to both the bar and the tone. During the conditions brain electrical activity will be recorded. You will also be asked to fill out mood questionnaires and rating of the facial pictures. Additionally, information on your diagnosis, other psychiatric diagnosis, length in the program, medications, primary stressor of PTSD onset and criminal charge will be provided to the researcher.

RISKS

The electrode sensors may cause temporary redness and irritation of the skin that will disappear in a few hours. Viewing some of the facial pictures may cause some participants to feel anxious; these feelings should not last longer than the 2.5 hour test session. A physician, nurse or medical staff will be available or on-call should their assistance be needed.

BENEFITS

There are no immediate benefits to you for taking part in this study. The study findings will be useful in further understanding brain processes in PTSD. This may help in the development of improved treatments.

PARTICIPATION

Your participation is voluntary and you may withdraw from the study at any time without penalty. Withdrawal from the study will not impact your care and treatment at the ROHCG. Dr. Cameron will not be directly informed if you choose to withdraw from the study, or choose not to participate. If you decide to withdraw during the test session, the data collected up to point of withdrawal will be retained for study analysis.

CONFIDENTIALITY

Information will be coded and your privacy will be protected. Any work resulting from this study will be presented so that you cannot be identified. Information collected from the study will be stored in a password-protected computer database (computer tasks) and kept in a locked storage room. The data will be kept for a period of 10 years after publication. After 10 years it
will be destroyed. At all times only the principal investigators (Dhrasti Shah, Verner Knott) will have access to this information. Research information may also be reviewed by the Royal Ottawa Research Ethics Board and/or the Research Quality Associate for quality assurance purposes.

I understand that the information I provide is confidential, and will never be revealed to anyone except under the following circumstances: if I disclose information about plans to harm myself or others, information concerning any unknown emotional, physical or sexual abuse of children, or information about any other criminal activities not already known to authorities, the researcher is required to report this information to the appropriate authorities.

INFORMATION

If you have any specific questions about this study, you should contact the principal investigator, Dhrasti Shah (613-722-6521 ext. 6254).

If you have any general questions regarding the ethics of this study, you may contact the Chairman of the Royal Ottawa Research Ethics Board, Dr. Douglass (613-722-6521 ext 6226).

University of Ottawa
Institute of Mental Health Research

Services de santé
Royal Ottawa
Health Care Group

CONSENT FORM

Title of Proposal: An Electrophysiological Investigation of Attentional Bias and Divided Attention in a Forensic PTSD Population.

Principal Investigator: Dhrasti Shah M.A. (cand.), Verner Knott, D.Phil., C.Psych.

Statement: I, ________________, agree to participate in the above described research project, the procedure and possible risks have been explained to me as outlined in the attached informed consent.

I agree to stay away from alcohol, drugs, caffeine and tobacco beginning at midnight before the test session. I agree to not have any food one hour prior to testing.

I understand that there are side effects with the study and these have been explained to me.

I understand that I may drop out of the study at any time for any reason. I understand that if I drop out it will not affect any clinical services or treatment that I may need. Additionally, if I fail to cooperate or adhere to the protocol, I will be re-booked or withdrawn from the study.

If I have any questions about the research, I understand that my questions will be answered by Dhrasti Shah, who can be contacted by telephone at (613) 722-6521, ext 6254.

________________________	____________________	________________
Name of Volunteer (printed)	Signature of Volunteer	Date
________________________	____________________	________________
Name of Investigator (printed)	Signature of Investigator	Date

6.3 APPENDIX C: CONTROL CONSENT FORM

University of Ottawa
Institute of Mental Health Research

Services de santé
Royal Ottawa
Health Care Group

INFORMATION SHEET (Patient Version)

Title of Proposal: An Electrophysiological Investigation of Attentional Bias and Divided Attention in a Forensic Posttraumatic Stress Disorder (PTSD) Population.

Principal Investigators: Dhrasti Shah, M.A. (cand.), Verner Knott, D.Phil., C.Psych.

INTRODUCTION

Please take time to read carefully and think about the information before you give your consent to be a research volunteer in this study. This information describes the purpose and procedures. It also explains the possible risks and benefits of the proposed research. Feel free to discuss any questions with the study investigators. You will receive a copy of this information sheet if you consent to participate. This study will be conducted in English only.

BACKGROUND

People with PTSD quickly focus their attention to fearful information. The specific brain processes that cause this in PTSD are not known. Distraction by pleasant information may reduce attention to fearful events. Brain processing of fearful events is needed to understand how PTSD patients process this information with and without a distraction. This understanding may help find other treatments for this disorder.

PURPOSE

This study wants to understand how the brain responds to threatening facial pictures. The aim is to understand the difference between brain responses with and without distraction. This will involve measuring brain electrical activity from the surface of the scalp. This provides us with a harmless way of measuring brain activity while looking at threatening and non-threatening facial pairs. There are two aims of this study. (1) Compare the brain activity of PTSD volunteers with controls in response to fearful facial expressions (e.g. fear, anger) versus non-fearful facial expressions. (2) Compare brain activity during distraction and no-distraction. The study will also use self-report questionnaires to review the participants feeling of the facial expressions.

PROCEDURES

Before the test session in the laboratory, you will be interviewed by a study investigator. You will be asked questions about your mental and physical health. This will take approximately 30 minutes. You will participate in one, 2.5-hour test session. You will be asked to not use alcohol, drugs, nicotine, caffeine or medication beginning at maximum 24 hours before the 10:00 a.m. test session. During test session, sensors will be placed on your scalp and around your eyes. This will monitor electrical activity of the brain. Once the sensors are in place, you will finish under three different conditions. In one condition you will be asked to press the response key when a bar is presented on the screen. While you are carrying out this task facial expressions will appear on the screen (e.g. angry, fearful) and you will hear sounds through head phones. In another condition you will be asked to ignore the bar and respond to the sounds. In third condition you will be asked to respond to both the bar and the tone. During the conditions brain electrical activity will be recorded. You will also be asked to fill out mood questionnaires and rating of the facial pictures. Additionally, information on your diagnosis, other psychiatric diagnosis, length in the program, medications, primary stressor of PTSD onset and criminal charge will be provided to the researcher.

RISKS

The electrode sensors may cause temporary redness and irritation of the skin that will disappear in a few hours. Viewing some of the facial pictures may cause some participants to feel anxious; these feelings should not last longer than the 2.5 hour test session. A physician, nurse or medical staff will be available or on-call should their assistance be needed.

BENEFITS

There are no immediate benefits to you for taking part in this study but a contribution of $25 will be allocated **to** your individual fund to buy materials such as books, art supplies, therapeutic CDs/DVDs, etc. The study findings will be useful in further understanding brain processes in PTSD. This may help in the development of improved treatments.

PARTICIPATION

Your participation is voluntary and you may withdraw from the study at any time without penalty. Withdrawal from the study will not impact your care and treatment at the ROHCG. **Dr. Cameron will not be directly informed if you choose to withdraw from the study, or choose not to participate.** If you decide to withdraw during the test session, the data collected up to point of withdrawal will be retained for study analysis. If you choose **to** withdraw from the study, you will be compensated ($25) for you time.

CONFIDENTIALITY

Information will be coded and your privacy will be protected. Any work resulting from this study will be presented so that you cannot be identified. Information collected from the study will be stored in a password-protected computer database (computer tasks) and kept in a locked storage room. The data will be kept for a period of 10 years after publication. After 10 years it will be destroyed. At all times only the principal investigators (**Dhrasti Shah, Verner Knott**) will have access to this information. Research information may also be reviewed by the Royal Ottawa Research Ethics Board and/or the Research Quality Associate for quality assurance purposes.

INFORMATION

If you have any specific questions about this study, you should contact the principal investigator, Dhrasti Shah (613-722-6521 ext. 6254).

If you have any general questions regarding the ethics of this study, you may contact the Chairman of the Royal Ottawa Research Ethics Board, Dr. Douglass (613-722-6521 ext 6226).

University of Ottawa
Institute of Mental Health Research

Services de santé
Royal Ottawa
Health Care Group

CONSENT FORM

Title of Proposal: An Electrophysiological Investigation of Attentional Bias and Divided Attention in a Forensic PTSD Population.

Principal Investigator: Dhrasti Shah M.A. (cand.), Verner Knott, D.Phil., C.Psych.

Statement: I, _______________, agree to participate in the above described research project, the procedure and possible risks have been explained to me as outlined in the attached informed consent.

I agree to stay away from alcohol, medication, drugs, caffeine and tobacco beginning at midnight before the test session. I agree to stay away from my prescribed medication **beginning a maximum of 24 hours before test session. Meaning, I agree not to take any of my prescribed medication, at the longest, 24 hours before the test session.** I agree to not have any food one hour prior to testing.

I understand that there are side effects with the study and these have been explained to me.

I understand that I may drop out of the study at any time for any reason. I understand that if I drop out it will not affect any clinical services or treatment that I may need. Additionally, if **I** fail to cooperate or adhere to the protocol, **I** will be re-booked or withdrawn from the study.

If I have any questions about the research, I understand that my questions will be answered by Dhrasti Shah, who can be contacted by telephone at (613) 722-6521, ext 6254.

______________________	______________________	______________
Name of Volunteer (printed)	Signature of Volunteer	Date
______________________	______________________	______________
Name of Investigator (printed)	Signature of Investigator	Date

6.4 APPENDIX D: SCREENING QUESTIONNAIRE

PTSD STUDY
CONTROL VOLUNTEER

Screening Questionnaire:

Date: ________________ ID#: **C**_________

Name: ____________________________ Age: _____ DOB (dd/mm/yy): ___________

Handedness: *Left / Right* Normal hearing: *Y / N* Vision: *Normal / Corrected*

Smoker:______ Years smoking: _____ # of cigarettes / day: ______

Telephone: (h) __________ (c) __________ (w) ___________
E-mail:______________

Education:________________
____

- Are you currently taking medication on a regular basis for any physical condition (e.g. pain)?
- NO YES: ____
- Have you had a head or brain injury in the past 6 months? ________________________________
  If yes, did you lose consciousness for one or more hours? __________________________
- Do you have a brain disorder, like epilepsy? ____
- Do you have high blood pressure? ____
- Do you have diabetes? ____
- Do you have any major allergies? ____

- Have you been diagnosed with a cardiac or respiratory condition?

  ____

SCID-Adapted Screening Questions

- Have you ever sought treatment or been treated for emotional or psychiatric problems?
  NO YES: ____________________

If YES: What for? Did you obtain any treatment? ____________________

- Have you ever sought treatment or been treated for drug or alcohol abuse?
  NO YES: ____________________

What is your daily (or weekly) alcohol consumption? __- ____________________

- Do you use street drugs? (e.g. marijuana, cocaine)
  NO YES: ____________________

If YES: What kind(s)? How Often?____________________- ____________________

MOOD EPISODES

Depressive

- Has there been a period of time when you were feeling depressed or down most of the day nearly, every day?
  NO YES: ____________________
- ...what about losing interest or pleasure in things you usually enjoy?
  NO YES: ____________________

(Skip the following if NO)

If YES: How long did this period last?____________________ ____________________

If YES: Just before this began were you:

- Physically ill? Drinking alcohol or using street drugs? Did this begin soon after someone close to you died?
  NO YES: ____________________

Manic

- Has there been a period of time when you were feeling so good, excited, or hyper that other people thought you were not your normal self or you were so hyper that you got into trouble?
  NO YES: ____________________

(Skip the following if NO)

If YES: How long did this period last?____________________ ____________________

If YES: Just before this began were you:

- Physically ill? Drinking alcohol or using street drugs?

NO YES:

ANXIETY DISORDERS

Panic

- Have you ever had a panic attack, when you suddenly felt frightened or suddenly developed a lot of physical symptoms?

NO YES:

(Skip the following if NO)

If YES: Have these attacks ever come on completely out of the blue – in situations where you don't expect to be nervous or uncomfortable?

NO YES:

(Skip the following if NO)

If YES: Just before you began having panic attacks, were you:

- Taking any drugs, caffeine, diet pills, or any other medications? Physically ill?

NO YES:

Agoraphobia

- Were you ever afraid of going out of the house alone, being in crowds, standing in a line or traveling on buses or trains?

NO YES:

(Skip the following if NO)

If YES: What were you afraid would happen?

Does participant mention anxiety about being in place/situation from escape may be difficult or embarrassing or in which help may not be available in the event of panic-like symptoms?

NO YES:

If YES: Just before you began having these fears, were you:

- Taking any drugs, caffeine, diet pills, or any other medications? Physically ill?

NO YES:

Social Phobia

- Is there anything that you have been afraid to do or felt uncomfortable doing in front of other people, like speaking, eating or writing?

NO YES:

:

(Skip the following if NO)
If YES to "Public Speaking": Do you think that you are more uncomfortable than most people who are in a similar situation?
NO YES:

IF YES: What were you afraid would happen?

Does participant mention that exposure to the feared social situation almost invariably provokes anxiety, which may take the form of a situationally bound or situationally predisposed panic-attack?
NO YES:

IF YES: Just before you began having these fears, were you:

- Taking any drugs, caffeine, diet pills, or any other medications? Physically ill?
NO YES:

GAD

- In the last six months, have you been particularly nervous or anxious?
NO YES:

:

(Skip the following if NO)
IF YES: What do you worry about?

During the past six months, would you say that you are worrying more often than not?
NO YES:

When you are worrying, do you find it difficult to stop?
NO YES:

When you're feeling anxious or nervous, do you feel:
___Restless ___Frequently tired ___Trouble concentrating/Mind goes blank
___Irritable
___Tense muscles ___Sleep disturbance

(3 of the above must be present)

PTSD

- Sometimes things happen to people that are extremely upsetting—things like being in a life threatening situation like a major disaster, very serious accident or fire; being physically assaulted or raped; seeing another person killed or dead, or badly hurt, or hearing about something horrible that has happened to someone you are close to. At any time during your life, have any of these kinds of things happened to you?

  NO YES:

(If No Skip the following)

If Yes:

List:____

Sometimes these things keep coming back in nightmares, flashbacks, or thoughts that you can't get rid of. Has that ever happened to you?

NO YES:

If No: What about being very upset when you were in a situation that reminded you of one of these terrible things?

(If No to both of Above Move on)

Have you every been convicted of a crime?

6.5 APPENDIX E: HANDEDNESS QUESTIONNAIRE

Date________________ ID#___________

Handedness Inventory

Please indicate your preferences in the use of hands in the following activities by putting + in the appropriate column. Where the preference is so strong that you would never try to use the other hand unless absolutely forced to, put ++. If any case you are really indifferent put + in both columns.

Some of the activities require both hands. In these cases the part of the task or object for which hand preference is wanted is indicated in brackets. Please try to answer all the questions and only leave a blank if you have no experience at all of the object or task.

Task	**Left**	**Right**
Writing		
Drawing		
Throwing		
Scissors		
Toothbrush		
Knife (without fork)		
Spoon		
Broom (upper hand)		
Striking match (match)		
Opening box (lid)		
Which foot do you prefer to kick with?		
Which eye do you use when using only one? (E.g. taking picture with a camera.)		

L.Q. _________ (Leave this space blank)

6.6 APPENDIX F: BECK DEPRESSION INVENTORY

Roche

V 0477

Beck Depression Inventory

CRTN: ____ CRF number: ____ Page 14

Baseline

patient inits: ________

BDI-II

Date:

Name: ______________ Marital Status: ________ Age: ______ Sex: _____

Occupation: ______________ Education: ______________

Instructions: This questionnaire consists of 21 groups of statements. Please read each group of statements carefully, and then pick out the **one statement** in each group that best describes the way you have been feeling during the **past two weeks, including today**. Circle the number beside the statement you have picked. If several statements in the group seem to apply equally well, circle the highest number for that group. Be sure that you do not choose more than one statement for any group, including Item 16 (Changes in Sleeping Pattern) or Item 18 (Changes in Appetite).

1. Sadness

0 I do not feel sad.
1 I feel sad much of the time.
2 I am sad all the time.
3 I am so sad or unhappy that I can't stand it.

2. Pessimism

0 I am not discouraged about my future.
1 I feel more discouraged about my future than I used to be.
2 I do not expect things to work out for me.
3 I feel my future is hopeless and will only get worse.

3. Past Failure

0 I do not feel like a failure.
1 I have failed more than I should have.
2 As I look back, I see a lot of failures.
3 I feel I am a total failure as a person.

4. Loss of Pleasure

0 I get as much pleasure as I ever did from the things I enjoy.
1 I don't enjoy things as much as I used to.
2 I get very little pleasure from the things I used to enjoy.
3 I can't get any pleasure from the things I used to enjoy.

5. Guilty Feelings

0 I don't feel particularly guilty.
1 I feel guilty over many things I have done or should have done.
2 I feel quite guilty most of the time.
3 I feel guilty all of the time.

6. Punishment Feelings

0 I don't feel I am being punished.
1 I feel I may be punished.
2 I expect to be punished.
3 I feel I am being punished.

7. Self-Dislike

0 I feel the same about myself as ever.
1 I have lost confidence in myself.
2 I am disappointed in myself.
3 I dislike myself.

8. Self-Criticalness

0 I don't criticize or blame myself more than usual.
1 I am more critical of myself than I used to be.
2 I criticize myself for all of my faults.
3 I blame myself for everything bad that happens.

9. Suicidal Thoughts or Wishes

0 I don't have any thoughts of killing myself.
1 I have thoughts of killing myself, but I would not carry them out.
2 I would like to kill myself.
3 I would kill myself if I had the chance.

10. Crying

0 I don't cry anymore than I used to.
1 I cry more than I used to.
2 I cry over every little thing.
3 I feel like crying, but I can't.

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San Diego • Philadelphia • Austin • Fort Worth • Toronto • London • Sydney

____ Subtotal Page 1

Continued on Back

0154018392
NR15645

Roche

V 0477

Beck Depression Inventory

CRTN: _____ CRF number: _____ Page 15 patient inits: ________

Baseline

11. Agitation
- 0 I am no more restless or wound up than usual.
- 1 I feel more restless or wound up than usual.
- 2 I am so restless or agitated that it's hard to stay still.
- 3 I am so restless or agitated that I have to keep moving or doing something.

12. Loss of Interest
- 0 I have not lost interest in other people or activities.
- 1 I am less interested in other people or things than before.
- 2 I have lost most of my interest in other people or things.
- 3 It's hard to get interested in anything.

13. Indecisiveness
- 0 I make decisions about as well as ever.
- 1 I find it more difficult to make decisions than usual.
- 2 I have much greater difficulty in making decisions than I used to.
- 3 I have trouble making any decisions.

14. Worthlessness
- 0 I do not feel I am worthless.
- 1 I don't consider myself as worthwhile and useful as I used to.
- 2 I feel more worthless as compared to other people.
- 3 I feel utterly worthless.

15. Loss of Energy
- 0 I have as much energy as ever.
- 1 I have less energy than I used to have.
- 2 I don't have enough energy to do very much.
- 3 I don't have enough energy to do anything.

16. Changes in Sleeping Pattern
- 0 I have not experienced any change in my sleeping pattern.
- 1a I sleep somewhat more than usual.
- 1b I sleep somewhat less than usual.
- 2a I sleep a lot more than usual.
- 2b I sleep a lot less than usual.
- 3a I sleep most of the day.
- 3b I wake up 1–2 hours early and can't get back to sleep.

17. Irritability
- 0 I am no more irritable than usual.
- 1 I am more irritable than usual.
- 2 I am much more irritable than usual.
- 3 I am irritable all the time.

18. Changes in Appetite
- 0 I have not experienced any change in my appetite.
- 1a My appetite is somewhat less than usual.
- 1b My appetite is somewhat greater than usual.
- 2a My appetite is much less than before.
- 2b My appetite is much greater than usual.
- 3a I have no appetite at all.
- 3b I crave food all the time.

19. Concentration Difficulty
- 0 I can concentrate as well as ever.
- 1 I can't concentrate as well as usual.
- 2 It's hard to keep my mind on anything for very long.
- 3 I find I can't concentrate on anything.

20. Tiredness or Fatigue
- 0 I am no more tired or fatigued than usual.
- 1 I get more tired or fatigued more easily than usual.
- 2 I am too tired or fatigued to do a lot of the things I used to do.
- 3 I am too tired or fatigued to do most of the things I used to do.

21. Loss of Interest in Sex
- 0 I have not noticed any recent change in my interest in sex.
- 1 I am less interested in sex than I used to be.
- 2 I am much less interested in sex now.
- 3 I have lost interest in sex completely.

3 4 5 6 7 8 9 10 11 12 A B C D E

____ Subtotal Page 2

____ Subtotal Page 1

____ Total Score

NR15645

6.7 APPENDIX G: POMS

NAME ______________________ DATE ____________

SEX: Male Ⓜ Female Ⓕ

IDENTIFICATION

Below is a list of words that describe feelings people have. Please read each one carefully. Then fill in ONE circle under the answer to the right which best describes HOW YOU HAVE BEEN FEELING DURING THE PAST WEEK INCLUDING TODAY.

The numbers refer to these phrases.

0 = Not at all
1 = A little
2 = Moderately
3 = Quite a bit
4 = Extremely

Col © O.P. ©

Item	NOT AT ALL	A LITTLE	MODERATELY	QUITE A BIT	EXTREMELY
1. Friendly	0	1	2	3	4
2. Tense	0	1	2	3	4
3. Angry	0	1	2	3	4
4. Worn out	0	1	2	3	4
5. Unhappy	0	1	2	3	4
6. Clear-headed	0	1	2	3	4
7. Lively	0	1	2	3	4
8. Confused	0	1	2	3	4
9. Sorry for things done	0	1	2	3	4
10. Shaky	0	1	2	3	4
11. Listless	0	1	2	3	4
12. Peeved	0	1	2	3	4
13. Considerate	0	1	2	3	4
14. Sad	0	1	2	3	4
15. Active	0	1	2	3	4
16. On edge	0	1	2	3	4
17. Grouchy	0	1	2	3	4
18. Blue	0	1	2	3	4
19. Energetic	0	1	2	3	4
20. Panicky	0	1	2	3	4
21. Hopeless	0	1	2	3	4
22. Relaxed	0	1	2	3	4
23. Unworthy	0	1	2	3	4
24. Spiteful	0	1	2	3	4
25. Sympathetic	0	1	2	3	4
26. Uneasy	0	1	2	3	4
27. Restless	0	1	2	3	4
28. Unable to concentrate	0	1	2	3	4
29. Fatigued	0	1	2	3	4
30. Helpful	0	1	2	3	4
31. Annoyed	0	1	2	3	4
32. Discouraged	0	1	2	3	4
33. Resentful	0	1	2	3	4
34. Nervous	0	1	2	3	4
35. Lonely	0	1	2	3	4
36. Miserable	0	1	2	3	4
37. Muddled	0	1	2	3	4
38. Cheerful	0	1	2	3	4
39. Bitter	0	1	2	3	4
40. Exhausted	0	1	2	3	4
41. Anxious	0	1	2	3	4
42. Ready to fight	0	1	2	3	4
43. Good natured	0	1	2	3	4
44. Gloomy	0	1	2	3	4
45. Desperate	0	1	2	3	4
46. Sluggish	0	1	2	3	4
47. Rebellious	0	1	2	3	4
48. Helpless	0	1	2	3	4
49. Weary	0	1	2	3	4
50. Bewildered	0	1	2	3	4
51. Alert	0	1	2	3	4
52. Deceived	0	1	2	3	4
53. Furious	0	1	2	3	4
54. Efficient	0	1	2	3	4
55. Trusting	0	1	2	3	4
56. Full of pep	0	1	2	3	4
57. Bad-tempered	0	1	2	3	4
58. Worthless	0	1	2	3	4
59. Forgetful	0	1	2	3	4
60. Carefree	0	1	2	3	4
61. Terrified	0	1	2	3	4
62. Guilty	0	1	2	3	4
63. Vigorous	0	1	2	3	4
64. Uncertain about things	0	1	2	3	4
65. Bushed	0	1	2	3	4

MAKE SURE YOU HAVE ANSWERED EVERY ITEM.

POM 021

6.8 APPENDIX I: BECK ANXIETY INVENTORY

BECK ANXIETY INVENTORY

Below is a list of common symptoms of anxiety. Please carefully read each item in the list. Indicate how much you have been bothered by that symptom during the past month, including today, by circling the number in the corresponding space in the column next to each symptom.

	Not At All	Mildly but it didn't bother me much.	Moderately - it wasn't pleasant at times	Severely – it bothered me a lot
Numbness or tingling	0	1	2	3
Feeling hot	0	1	2	3
Wobbliness in legs	0	1	2	3
Unable to relax	0	1	2	3
Fear of worst happening	0	1	2	3
Dizzy or lightheaded	0	1	2	3
Heart pounding/racing	0	1	2	3
Unsteady	0	1	2	3
Terrified or afraid	0	1	2	3
Nervous	0	1	2	3
Feeling of choking	0	1	2	3
Hands trembling	0	1	2	3
Shaky / unsteady	0	1	2	3
Fear of losing control	0	1	2	3
Difficulty in breathing	0	1	2	3
Fear of dying	0	1	2	3
Scared	0	1	2	3
Indigestion	0	1	2	3
Faint / lightheaded	0	1	2	3
Face flushed	0	1	2	3
Hot/cold sweats	0	1	2	3
Column Sum				

6.9 APPENDIX J: STATE ANXIETY

DATE:__________ **ID:**__________ **TASK**__________

STA-Y

INSTRUCTIONS: A number of statements which people have used to describe themselves are given below. Read each statement and circle an answer to indicate how you feel *right now*, that is, at this moment. There are no right or wrong answers. Do not spend too much time on any one statement, but give the answer which seems to describe your present feelings best.

		Not at all	Somewhat	*Moderately so*	Very Much so
1.	**I feel calm**	1	2	3	4
2.	I feel secure	1	2	3	4
3.	I am tense	1	2	3	4
4.	I feel strained	1	2	3	4
5.	I feel at ease	1	2	3	4
6.	**I feel upset**	1	2	3	4
7.	I am presently worrying over possible misfortunes	1	2	3	4
8.	I feel satisfied	1	2	3	4
9.	I feel frightened	1	2	3	4
10.	**I feel comfortable**	1	2	3	4
11.	I feel self-confident	1	2	3	4
12.	I feel nervous	1	2	3	4
13.	I am jittery	1	2	3	4
14.	I feel indecisive	1	2	3	4
15.	I am relaxed	1	2	3	4
16.	I feel content	1	2	3	4
17.	I am worried	1	2	3	4
18.	I feel confused	1	2	3	4
19.	I feel steady	1	2	3	4
20.	I feel pleasant	1	2	3	4

6.10 APPENDIX K: TRAIT ANXIETY

DATE:__________ **ID:**__________

TAI-Y

INSTRUCTIONS: A number of statements which people have used to describe themselves are given below. Read each statement and then circle an answer sheet to indicate how you generally feel. There are no right or wrong answers. Do not spend too much time on any one statement, but give the answer which seems to describe how you generally feel.

		Almost Never	Sometimes	*Often*	Almost Always
1.	I feel pleasant	1	2	3	4
2.	I feel nervous and restless	1	2	3	4
3.	I feel satisfied with myself	1	2	3	4
4.	I wish I could be as happy as others seem to be	1	2	3	4
5.	I feel like a failure	1	2	3	4
6.	I feel rested	1	2	3	4
7.	I am "calm, cool, and collected"	1	2	3	4
8.	I feel that difficulties are piling up so that I cannot overcome them	1	2	3	4
9.	I worry too much over something that really doesn't matter	1	2	3	4
10.	I am happy	1	2	3	4
11.	I have disturbing thoughts	1	2	3	4
12.	I lack self-confidence	1	2	3	4
13.	I feel secure	1	2	3	4
14.	I make decisions easily	1	2	3	4
15.	I feel inadequate	1	2	3	4
16.	I am content	1	2	3	4
17.	Some unimportant thought runs through my mind and bothers me	1	2	3	4
18.	I take disappointments so keenly that I can't put them out of my mind	1	2	3	4
19.	I am a steady person	1	2	3	4
20.	I get in a state of tension or turmoil as I think about my recent concerns and interests	1	2	3	4

6.11 APPENDIX L: PCL

PTSD CheckList – Civilian Version (PCL-C)
Client's Name: ______________________________
Instruction to patient: Below is a list of problems and complaints that veterans sometimes have in response to stressful life
experiences. Please read each one carefully, put an "X" in the box to indicate how much you have been bothered by that problem *in the last month.*
No. Response Not at all (1) A little bit (2) Moderately (3) Quite a bit (4) Extremely (5)

1. Repeated, disturbing *memories, thoughts, or images* of a stressful experience from the past?
2. Repeated, disturbing *dreams* of a stressful experience from the past?
3. Suddenly *acting* or *feeling* as if a stressful experience *were happening* again (as if you were reliving it)?
4. Feeling *very upset* when *something reminded* you of a stressful experience from the past?
5. Having *physical reactions* (e.g., heart pounding, trouble breathing, or sweating) when *something*
reminded you of a stressful experience from the past?
6. Avoid *thinking about* or *talking about* a stressful experience from the past or avoid *having feelings* related to it?
7. Avoid *activities* or *situations* because they *remind you* of a stressful experience from the past?
8. Trouble *remembering important parts* of a stressful experience from the past?
9. Loss of *interest in things that you used to enjoy?*
10. Feeling *distant* or *cut* off from other people?
11. Feeling *emotionally numb* or being unable to have loving feelings for those close to you?
12. Feeling as if your *future* will somehow be *cut short*?
13. Trouble *falling* or *staying asleep*?
14. Feeling *irritable* or having *angry outbursts*?
15. Having *difficulty concentrating*?
16. Being *"super alert"* or watchful on guard?
17. Feeling *jumpy* or easily startled?

PCL-M for DSM-IV (11/1/94) Weathers, Litz, Huska, & Keane National Center for

PTSD - Behavioral Science Division

6.12 APPENDIX M: IES-REVISED

IMPACT OF EVENT SCALE-REVISED

Instructions: The following is a list of difficulties people sometimes have after stressful life events. Please read each item, and then indicate how distressing each difficulty has been for you *during the past 7 days* with respect to the disaster. How much were you distressed or bothered by these difficulties?

		Not at all	A little bit	Moderately	Quite a bit	Extremely
1	Any reminder brought back feelings about it.	0	1	2	3	4
2	I had trouble staying asleep.	0	1	2	3	4
3	Other things kept making me think about it.	0	1	2	3	4
4	I felt irritable and angry.	0	1	2	3	4
5	I avoided letting myself get upset when I thought about it or was reminded of it.	0	1	2	3	4
6	I thought about it when I didn't mean to.	0	1	2	3	4
7	I felt as if it hadn't happened or wasn't real.	0	1	2	3	4
8	I stayed away from reminders about it.	0	1	2	3	4
9	Pictures about it popped into my mind.	0	1	2	3	4
10	I was jumpy and easily startled.	0	1	2	3	4
11	I tried not to think about it.	0	1	2	3	4
12	I was aware that I still had a lot of	0	1	2	3	4

	feelings about it, but I didn't deal with them.					
13	My feelings about it were kind of numb.	0	1	2	3	4
14	I found myself acting or feeling like I was back at that time.	0	1	2	3	4
15	I had trouble falling asleep.	0	1	2	3	4
16	I had waves of strong feelings about it.	0	1	2	3	4
17	I tried to remove it from my memory.	0	1	2	3	4
18	I had trouble concentrating.	0	1	2	3	4
19	Reminders of it caused me to have physical reactions, such as sweating, trouble breathing, nausea, or a pounding heart.	0	1	2	3	4
20	I had dreams about it.	0	1	2	3	4
21	I felt watchful and on guard.	0	1	2	3	4
22	I tried not to talk about it.	0	1	2	3	4