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Attention to novel and target stimuli in trauma survivors

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ABSTRACT

Trauma and its consequences can have lasting biological and cognitive effects on those who experience them. This study investigated the extent to which trauma, posttraumatic stress disorder (PTSD), and dissociation influenced attention to basic auditory stimuli in a sample of military cadets. After filling out a series of psychometric questionnaires, 27 male military cadets varying in their trauma history participated in the "novelty" oddball task in which participants were asked to count high-pitched tones while ignoring other auditory stimuli. Electroencephalogram (EEG) was continually recorded in order to assess P300 responses, an event-related potential (ERP) associated with attention and memory processes. Trauma history only, and not dissociation or PTSD scores, predicted smaller P300 amplitudes to target tones. To distracting novel sounds, only trauma history and dissociation predicted unique variance in P300 amplitudes. The findings suggest that PTSD may not be central to the attentional disturbances found in traumatized samples, while trauma history and dissociation may play a more important role. Future studies investigating attentional processes post trauma should utilize dissociation scales and a non-trauma sample.

1. Introduction

Attentional difficulties post trauma have been well documented and it has been widely assumed that these attentional disturbances are due to posttraumatic stress disorder (PTSD), the hallmark post trauma disorder (Buckley et al., 2000; Vasterling et al., 2002; Karl et al., 2006a,b). However, there is growing evidence to suggest that some of these difficulties may be due to the trauma itself or a concurrent psychiatric condition, such as dissociation. For example, some attention-related tasks (such as the modified Stroop and oddball P300 tasks) have found attentional biases that are likely due to the trauma alone (Karl et al., 2006a,b; Kimble et al., 2009). Likewise, in the highly comorbid dissociative disorders, disturbances in attention are extensive and are thought to underlie many of the unusual sensory experiences and amnestic qualities of the disorders (APA, 2000; Dorahy and Huntjens, 2007).

In trying to understand attention post trauma, most studies to date have taken a traumatized sample and divided it into those with and without PTSD. Few studies have taken into consideration the effect of the trauma itself and the contributions of concurrent dissociative symptoms. Because attentional disturbances are likely the cause of many functional impairments seen post trauma, characterizing the nature, extent, and source of these attentional disturbances becomes important.

While there are a variety of strategies to do so, event-related potentials (ERPs) provide a sensitive and non-invasive technique to assess attentional processing. ERPs are segments of the electroencephalogram (EEG) that are time locked to stimulus presentation. By presenting the stimulus multiple times and then averaging the brain's response to that stimulus, an event-related brain potential can be recorded and evaluated.

One ERP in particular, the P300, has been widely used to study attentional processes in both normal and clinical populations. The P300 is a positive brain potential that occurs approximately 300 ms after the onset of the stimulus. Under appropriate conditions, the amplitude of the P300 indexes response categorization and the depth of encoding of the stimuli — larger amplitude P300s are thought to represent the amount of processing necessary to update neural networks about the changing environment. While there are a number of complementary and competing models of P300 (Donchin and Coles, 1998; Nieuwenhuis et al., 2005; Polich, 2007) and a number of identified factors that affect the amplitude and latency of the P300 (Johnson, 1986; Polich and Kok, 1995; Donchin and Coles, 1998), all agree that stimuli garnering more attentional resources produce larger amplitude P300s. The utility of the P300 in studying psychopathological populations is supported by evidence showing P300 abnormalities in psychiatric groups that report significant difficulties in stimulus processing (Polich et al., 1994; Blackwood, 2000; Yang-Wang and Polich, 2003; Karl et al., 2006b).

For these reasons the P300 is the most widely studied ERP in individuals with trauma histories (Charles et al., 1995; Attias et al., 1996; Metzger et al., 1997; Kimble et al., 2000; Stanford et al., 2001;

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Felmingham et al., 2002; Metzger et al., 2002; Neylan et al., 2003; Kirino et al., 2006; Schucard et al., 2008). In a recent meta-analysis of P300 studies in those with trauma histories, Karl et al. (2006b) concluded that individuals with PTSD show variations in P300 amplitude and latency, and the variations depend on the valence of the stimulus, the context in which the stimulus is presented, and whether the P300 is elicited to a target stimulus or a distracting stimulus. The authors made three tentative conclusions about the P300 in PTSD, 1) that the P300 to neutral stimuli are reduced, indicating poorer concentration 2) that the P300 to trauma stimuli are enhanced, indicating increased attention, and 3) that the P300 to neutral stimuli presented in the context of trauma-related cues are also enhanced. This pattern is consistent with clinical reports of both “concentration difficulties” and “hypervigilance” in PTSD.

However, Karl et al. (2006b) acknowledge that many published studies do not fit this pattern and call for continued refinement of findings as they relate to trauma survivors. There are three clear gaps in the literature that would expand our understanding of attention after trauma. First, comorbidities have been largely unaddressed in the trauma ERP literature despite the likelihood that comorbid disorders impact attentional processes as well. Second, studies rarely include a non-traumatized sample in order to look at the potential effects of trauma itself (and not just symptom presentation) on attentional processing. Finally, almost all previous approaches have been categorical in nature and therefore have dichotomously placed trauma survivors into either “PTSD” or “No PTSD” categories. Such an approach ignores the fact that many trauma survivors are subsyndromal, or that symptom presentation occurs on a continuum post trauma, and the presentation may be primarily dissociative.

The current study addresses all three of these issues. The study evaluated not only PTSD symptoms but also dissociation symptoms. It also included non-traumatized individuals to assess the impact of trauma itself as a factor. Finally, it measured post-trauma symptoms continuously using valid and reliable scales in order to take advantage of the natural variability present in the population.

Only few pieces of work have looked at aspects of the above-mentioned goals. Kaufman (2002) was the first to use ERPs and the P300 to investigate the effects of dissociation on attentional processes. Kaufman found that those high in dissociation showed smaller and delayed P300s relative to those low in dissociation in an all PTSD combat veteran sample. Kirino (2006) reported smaller P300s during dissociative episodes which recovered during remission. In the current study, continuous measures of dissociation and PTSD were used to predict P300 characteristics but used a young sample of military cadets who also varied in their trauma history. Therefore, we were able to investigate these relationships between P300, trauma, and psychopathology in the absence of long-term medication use, chronic mental health issues, and long periods between the trauma and the assessment.

2. Methods

2.1. Participants

Twenty-seven male military cadets participated in the study. The age range was from 18 to 23. One participant was Asian and two identified themselves as Hispanic. Cadets are undergraduate students, not military personnel, who typically intend to commission as an officer into a branch of the military upon graduation. Some cadets have served or are currently serving in active duty in reserve units. In this study, three of the cadets were combat veterans who were returning for degrees and seeking commissioning as an officer. Participants were recruited through introductory psychology courses and received course credit for their participation. This paradigm and the measures were part of a larger behavioral/ERP study of stereotype threat from which results have been reported elsewhere (Fleming et al., 2010). No participants had a history or head injury resulting in a loss of consciousness longer than 5 min and none reported a history of epilepsy or seizures. Substance abuse history was not evaluated. Periodic use is possible; however, chronic use is unlikely because the cadets are young, the campus is “dry,” and penalties for substance use in the cadet corps are severe.

2.2. Procedures

Participation began with a written informed consent procedure. This was followed by administration of a modified version of the Trauma Experiences Questionnaire (Vrana and Lauterbach, 1994) which concluded with an open-ended written account of their most difficult traumatic experience. This allowed for assessment of criteria A1 and A2 to assess the presence of a traumatic event as defined by current American Psychological Association (APA) criteria. The participants also filled out the PTSD Symptom Scale (PSS: Foa et al., 1993), and the Dissociative Experience Scale (DES: Carlson and Putnam, 1993). This paperwork was followed by the ERP task. Participants sat in a straight-backed chair inside an experimental chamber while 30 Ag/AgCl electrodes embedded in an elastic cap (Electro-cap International: Eaton, OH) were positioned using an augmented 10–20 electrode configuration. All other electrodes were positioned automatically at standard relative distances. An average reference was used. Electrode impedances were maintained below 10,000 Ω (10 kΩ) at all recording electrodes. Each subject's EEG was amplified using a Neuroscan NuAmps digital EEG amplifier (El Paso, TX). NuAmps amplifiers have a fixed gain of 19 in direct-current (DC) mode with a 22 bit resolution. The high resolution, DC recording allows for low gain settings. Data were sampled at the rate of 250 Hz, with a high pass filter at 0.01 Hz and the low pass filter at 30 Hz. Recording was continuous. EEG data were stored offline on a Dell Latitude 820 laptop computer for later analyses. All data acquisition, filtering, and averaging were completed using Neuroscan ERP editing software (El Paso, TX, USA).

2.3. Task

Once the electrodes were secure, the subject was instructed about the task. The novelty “oddball” task consisted of presentations of 300 auditory stimuli. Eighty percent of the stimuli were 1000 Hz, 55 dB pure tones (“frequents”) presented for 50 ms with a rise and fall time of 5 ms. Ten percent of the stimuli were rare 2000 Hz tones (“targets”), which were identical in all other parameters to the “frequent” tones. The other 10% of the stimuli were unique, non-repeating sound effects (“novels”) either sampled from a sound effects compact disk or generated in the lab using a microphone. These stimuli are similar to those used by Kimble et al. (2000, 2001). Typical novel sounds were computer-generated whistles or buzzes and recordings of typical environmental sounds (e.g., a key in a lock, a cup being placed on a table.). The novel sounds, were clipped to a length of 200 ms and were unidentifiable and ambiguous. The intensities of all stimuli, including novel sounds, were checked using a calibrated sound level meter (Radio Shack 33-2055). The interstimulus interval was 1500 ms. For the entire task, 240 frequent stimuli, 30 novel, and 30 target stimuli were presented.

The subjects were instructed that they would hear a series of tones in which target high-pitched tones were randomly interspersed. They were asked to ignore all other sounds, and silently count the high-pitched “target” tones. Accuracy rates for all participants were over 90%. When the subject indicated that he understood the instructions, the task began.

2.4. Data reduction

EEG was epoched offline with a 100 ms prestimulus interval and 1000 poststimulus interval. All trials were baseline corrected and corrected for eye blinks using Neuroscan 4.2 ocular artifact correction routine (Semlitsch et al., 1986). For each subject, all trials were averaged per condition (frequent, target, and novels). Baseline was established as the average of EEG from −100 to 0 ms prior to the onset of the stimulus. The P300 was measured using a baseline to peak measure. Any average artifact rejection routine was used (set at +75 and −75 uV); however, visual inspection of the waveforms at electrodes of interest indicated this had little effect on the data. Therefore, the routine was not used in order to retain more trials, and the average for each condition for each participant consisted of 30 novel and 30 target stimuli.

ERPs to frequent, novel, and target stimuli are shown in Fig. 1. Consistent with previous research in clinical and non-clinical populations, the P300 to the novels was frontally/centrally distributed and the P300 to targets was parietal (Friedman et al., 2001; Polich, 2007) In this study, the largest P300 to novels was at the Cz electrode and the P300 to targets was maximal at Pz. Therefore, the amplitude and latency of the P300 to novel sounds were measured at a frontal/central montage that included FCz, Cz, CPz, C3, and C4. This montage consisted of the Cz electrode and the four surrounding electrodes. The amplitude and latency of the target stimuli were measured at a parietal montage that included CPz, Pz, Oz, P3, and P4. This montage consisted of the Pz electrode and the four surrounding electrodes. The reporting of ERPs from these sites is more extensive than exists in the present P300/ERP literature (Charles et al., 1995; Attias et al., 1996; Metzger et al., 1997; Stanford et al., 2001; Metzger et al., 2002; Neylan et al., 2003; Schucard et al., 2008), but the montage minimizes the possibilities of spurious effects at a single site. In order to minimize error due to multiple comparisons (potentially as many as 20 because of amplitude and latency analyses at two 5-electrode montages), the amplitude and latency at a given montage were averaged across the five electrodes so a single value for a given montage could be entered for the multiple regression. ERPs were recorded from additional sites which contributed to the average reference.

The P300 to both target and novel stimuli were submitted to a hierarchical multiple regression with trauma entered first, and the symptoms scales (PSS and DES scores) entered second. Therefore, this analysis would first assess the affect of trauma history on P300 characteristics followed by the unique contributions of PTSD and dissociation

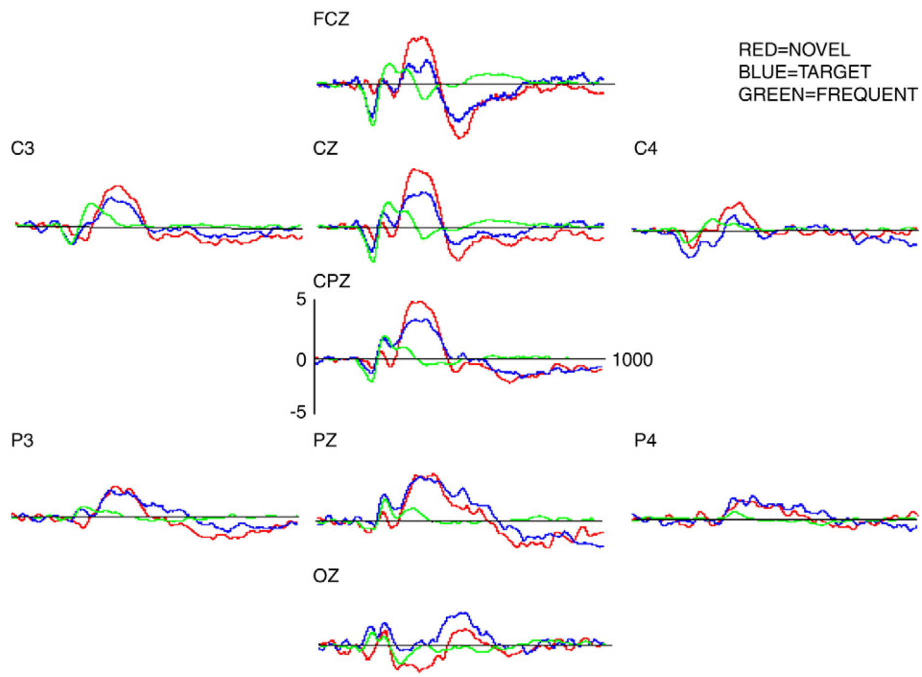

Fig. 1. ERPs to frequent, novel, and target stimuli in 27 military cadets. A "frontal" montage consisted of FCz, Cz, CPz, C3, and C4 and the average at these sites was used to analyze P300s to novel stimuli. A "parietal" montage of CPz, Pz, Oz, P3, and P4 and the average of these sites was used to analyze P300s to targets.

symptoms. An average P300 amplitude at the frontal/central montage to novel stimuli are analyzed first, followed by average targets amplitudes at the central/parietal montage. Latency analyses follow the same pattern. Therefore, four regressions are reported. Follow-up analyses are included as appropriate.

3. Results

3.1. Demographics

In this sample, 15 of the 27 participants reported a history of trauma that met criteria A1 and A2. Reported trauma included physical assault, combat exposure, significant exposure to the NY/Washington terrorist attacks, child abuse, natural disasters, and motor vehicle accidents. None reported rape or childhood sexual abuse. The mean for the PSS was 7.81 (7.9) with a range from 0 to 30. The mean for the DES was 9.97 (7.0) with a range from 0.90 to 26.6.

3.2. Transformations

Evaluations of the assumptions for multiple regression led to the transformation of one of the variables (Tabachnick and Fidell, 1989). The PSS was not normal in kurtosis and positively skewed, and a square root transformation was applied which brought the distribution within normal limits (from here on referred to as SQPSS). Transformations were not required for the DES. Some values for some participants were greater than 2 S.D. above the mean for the PSS and DES and thus potentially could be considered outliers. However, given that the values were meaningful and valid due to the content of the scales, these participants were not removed from the analyses. Examination of the distribution of the residuals indicated reasonable normality, linearity, and homoscedasticity. All subsequent analyses revealed both tolerance and variance inflation factor estimates to be within normal limits, indicating no problematic multicollinearity effects.

3.3. Regression analysis 1: predictors of P300 amplitude to novel stimuli

Trauma history was entered as the first step into the equation followed by step two, which included SQPSS and DES scores. The results of this analysis are presented in Table 1. Forty-one percent of the variance in P300 amplitude to novel sounds was accounted for by trauma history, DES, and SQPSS scores. R was significantly different from zero, $F(3,25) = 5.13$, $P < 0.01$. In the first step, trauma history predicted smaller P300s and was significant ($t = -2.30$, $P < 0.05$). Trauma history was also negative and significant in the second step ($t = -2.21$, $P < 0.05$) as were DES scores ($t = -2.82$, $P < 0.01$). PSS scores did not contribute significantly to regression. The bivariate relationship ($r = -0.51$, $P < 0.01$) between DES and novelty P300 amplitude is shown in Fig. 2.

3.4. Follow-up analyses of dissociative effects on novelty P300 amplitude

In order to better illustrate the relationship between dissociation and novelty P300 amplitude, a follow-up analysis of variance (ANOVA) was utilized. This analysis was conducted in order to investigate possible, nonlinear relationships between dissociation and P300 amplitude, an effect that would not be detected using regression analyses or bivariate correlations. This *post hoc* investigation would test whether the linear effects picked up in the correlations and regressions may be driven by those highest or lowest in DES scorers. A univariate ANOVA, in which the 27 participants were divided into low ($n = 9$), medium ($n = 9$), and high ($n = 9$) DES scores, showed a significant difference in novelty P300 amplitude [$F(3,26) = 7.19$, $P < 0.01$]. Least square difference (LSD) *post hoc* tests indicated that those high in dissociation had significantly smaller novelty P300 amplitudes compared to both the medium ($P < 0.01$) and low DES ($P < 0.01$) participants.

Table 1
Predictors of Novelty P300 amplitude: results of hierarchical multiple regression at the frontal/central montage.

Variable	B	SEB	*B*	*t*
Step 1				
Trauma	−1.81	1.17	−0.42	−2.30**
Step 2				
Trauma	−1.61	0.73	−0.38	−2.21**
DES	−0.15	0.05	−0.49	−2.82***
SQPSS	0.36	0.24	0.26	1.50

Note: $R^2 = 0.41$. *$P < 0.10$, **$P < 0.05$, ***$P < 0.01$.
DES = Dissociative Experiences, SQPSS = Square of Posttraumatic Stress Scale.

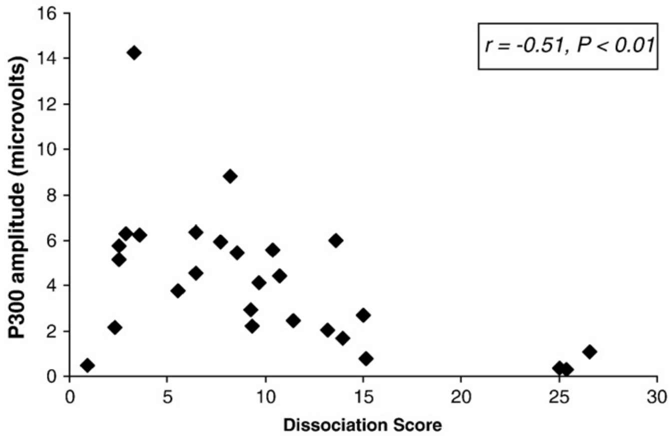

Fig. 2. P300 amplitude at the frontal/central montage as function of DES scores.

Effect size analyses indicate that the difference between the high DES group and the medium DES group (Cohen's $D=1.56$) and low DES group (Cohen's $D=1.22$) is robust. The Cohen's D between the low DES group and the medium DES group is 0.12. This suggests that not detecting the effect between these two groups is not likely due to the small sample size.

3.5. Regression analysis 2: predictors of P300 amplitude to target stimuli

Trauma history was entered as the first step in the equation, followed by step two, which included SQPSS and DES scores. The results of this analysis are presented in Table 2. Thirty percent of the variance in P300 amplitude to target tones was accounted for by trauma history, DES, and SQPSS scores. R was significantly different from zero, $F(3,25)=3.19$, $P<0.05$. In the first step trauma history predicted smaller P300s to targets ($t=-2.07$, $P=0.05$) and was also significant in the second step ($t=-2.18$, $P<0.05$). In the second step, neither DES nor SQPSS scores contributed significantly to the regression. Because dissociation nor PTSD was not a significant factor in this model, follow up analyses were not conducted on these variables.

3.6. Regression analyses 3–4: predictors of P300 latency to target and novel stimuli

In similarly structured hierarchical regressions, none of the independent variables predicted P300 latencies to either novel or target stimuli.

4. Discussion

4.1. Summary of the findings

In this study, a history of trauma predicted negative P300 amplitudes to both target and novel stimuli. PTSD scores did not predict the amplitude or latency of the P300 to novels or targets.

Table 2
Predictors of Target P300 amplitude: Results of hierarchical multiple regression at the parietal montage.

Variable	*B*	SEB	*Β*	t
Step 1				
Trauma	−1.01	0.49	−0.39	−2.07**
Step 2				
Trauma	−1.06	0.49	−0.41	−2.18**
DES	−0.55	0.04	−0.30	−1.57
SQPSS	0.30	0.16	0.35	1.86

Note: $R^2=0.30$, *$P<0.10$, **$P<0.05$, ***$P<0.01$.
DES = Dissociative Experiences, SQPSS = Square of Posttraumatic Stress Scale.

Dissociative symptoms, as measured by the DES, predicted additional variance in the P300 amplitude to novel sounds. This effect seemed to be driven primarily by those cadets with the highest DES scores. In total, the findings suggest that military cadets with trauma histories and those higher in dissociation demonstrate abnormalities in P300 amplitudes.

4.2. Trauma history and P300

Most studies that have looked at the P300 in trauma survivors have not included a non-trauma control group and this is the first to do so in a novelty P300 task. Reductions in P300 amplitude within a population could have multiple sources including dysfunction in multiple anatomical structures, abnormalities in neurotransmitter systems, or changes in top–down processes such as motivation and allocation of attention. As unlikely as it may seem that trauma alone might cause significant information processing deficits, the conclusion is consistent with a growing literature using functional and structural imaging indicating that trauma, even the absence of psychopathology, can create lasting changes (McEwen, 2000; McEwen and Lasley, 2007). For example, Vythilingam et al. (2002) found that depressed participants with a history of abuse had an 18% decrease in left hippocampal volume compared to depressed participants without a history of child abuse. In 2005, Vythilingam et al. (2005) found that all deployed veterans regardless of PTSD status had smaller whole hippocampal volume than a non-traumatized control group. Finding such as these resulted in a meta-analysis which concluded that trauma-exposed persons *without PTSD* showed smaller left and right sided hippocampal volumes compared to non-trauma controls (Karl et al., 2006a).

Now, added to that list of trauma-related changes is basic information processing. The data suggest that individuals with trauma histories are processing neutral auditory stimuli differently than those without a history of trauma. In pathological populations, P300 reductions are often interpreted as difficulty concentrating or a reduced allocation of attention to the study stimuli (McFarlane et al., 1993; Metzger et al., 1997). This interpretation arises from data showing that P300 is smaller when participants are distracted by another task, have high working memory load, or find stimulus discrimination difficult (Johnson, 1986; Katayama and Polich, 1998; Polich, 2007). However, in a traumatized sample or a sample with PTSD, such an interpretation is limiting because of the many circumstances in which such samples show larger P300s to trauma relevant or potentially threatening stimuli or contexts. (Attias et al., 1996; Bleich et al., 1996; Kimble et al., 2000; Stanford et al., 2001, Schucard et al., 2008). If there was some general difficulty due to distraction, working memory, or stimulus discrimination, there would not be enhancements in P300 to certain stimuli.

Therefore, it is worthwhile to consider the value and the relevance individuals with trauma history assign to study stimuli. In an early model of P300 amplitude, Johnson (1986) proposed "stimulus meaning" as one of the three primary determinants of P300 amplitude. Both before and after Johnson's paper, P300 has been shown to be reliably larger to stimuli with high personal relevance and motivational value (Johnson, 1986; Berlad and Pratt, 1995; Kodama et al., 1996; Gray et al., 2004; Ilardi et al., 2007; Goldstein et al., 2008). Such findings help explain the larger P300s to traumatic stimuli found in traumatized individuals with PTSD. However, in the absence of such salient stimuli, the relevance and value assigned to the stimuli in this task may be significantly less, producing small P300s to all study stimuli. Supporting this claim is evidence indicating that syndromes associated with low motivation, such as anhedonia or emotional numbing (Simons and Russo, 1987; Felmingham et al., 2002), also have smaller P300s to neutral stimuli. Trauma, even in the absence of psychopathology, has long been thought to change priorities and values (Janoff-Bulman, 1992; Zoellner and Maercker, 2006; Tedeschi et al., 2007), and it is possible that military cadets with trauma history may have difficulty assigning value or relevance to affectively neutral stimuli presented during a task that has little personal consequence.

4.3. Dissociation and P300

Overlaying these basic trauma findings is the additional influence of dissociation. The pattern in this study's findings, with dissociation affecting novel stimuli but not targets, is consistent with current models of information processing in dissociation. Absorption is a term often used to characterize attentional patterns in those who dissociate (Vermetten and Spiegel, 2007). This intense attentional focus on one stimulus results in the potential screening out of other, peripheral stimuli. It is these absorptive and dissociative attentional patterns that often lead others to characterize dissociaters as "spacey" or "in a daze." Once their attention is engaged, it is difficult to disengage, therefore intrusions and distractions may be easily missed. In a paradigm such as the novelty task, engagement with the primary task of counting the targets may have resulted in minimal processing of the irrelevant distracters for those high in dissociation.

One common debate in the dissociation literature is whether tertiary dissociation is functional or not. The findings in this study run counter to notions that dissociative attentional patterns are always counterproductive. In this novelty oddball task, one could argue that high dissociaters performed the task more efficiently as they effectively screened out the irrelevant, novel stimuli while processing the target tones in a manner consistent with those low in dissociation. The ability to screen out irrelevant stimuli can be either advantageous or detrimental depending on the context.

However, most have argued that the adequate detection of novel or salient distracting stimuli (i.e., orienting) has evolved with a clear purpose — to alert an organism to a new stimulus in the environment to allow for further evaluation (Friedman et al., 2001). The ability to screen out distracting stimuli is only advantageous if those stimuli are truly of no value, as was the case in this task. Clinically, it is important to know whether individuals can attend to novel stimuli when those stimuli are of importance and whether the 'dissociater' has any control over this process. Some neurobiological models of dissociation suggest that dissociaters might have some capacity to control attentional functioning as the thalamus receives input in a top–down fashion by cortical structures that modulate attention like the cingulate and the frontal cortex (Krystal et al., 1995). On the other hand, the model also suggests that excessive input from brain stem structures that modulate arousal like the locus coeruleus might overwhelm voluntary control in times of significant stress and anxiety.

It is important to note that individuals who report higher levels of dissociative symptoms may have patterns of attention that are distinct from the better known patterns of hypervigilance often seen in PTSD samples. It seems that those subjects with higher DES scores showed a pattern of attention that was not "hypervigilant", as would be reflected in *larger* P300 to novel sounds. In a previous study, we reported larger P300 to novel sounds in combat veterans with PTSD but did not have the benefit of using the DES to further analyze the findings (Kimble et al., 2000). At the very least, it seems clinically important to appreciate the dissociative profile if one wants to better understand attention in subjects with trauma, as those with dissociative tendencies may show very different attentional patterns than those without such tendencies. This is consistent with recent models by Bremner et al. (1999a,b) and Lanius et al. (2006) that argue for subtypes of PTSD; one dissociative and one non-dissociative.

Finally, the follow-up one-way ANOVA indicated that the P300 to novels was smaller only in the highest DES group (mean DES = 17.7), which was significantly different from both the medium DES ($\times = 8.9$) and low DES ($\times = 3.3$) groups. This group-level analysis suggests that only higher levels of dissociation may be associated with the screening out of peripheral stimuli. This pattern in the data which we did not predict at the outset, suggests that linear analyses such as regression and correlation may disguise an underlying nonlinear trend in which only those with the highest levels of dissociation show distinct patterns of response to peripheral and distracting stimuli.

4.4. Limitations

This study was limited in its ability to assess third variables that could account for the relationship between trauma, dissociation, and reduced P300s. Variables left unstudied in this sample, such as histories of childhood emotional abuse or neglect or physical abuse or neglect, may account for the effects on P300 that we attributed to dissociation or an easily identifiable trauma. Although anecdotal, military cadets are often thought to come from family and social economic backgrounds associated with hardship in which trauma may be more prevalent than in the average college population. This longer-term exposure to a negative childhood environment may be an underlying variable that leads to an identifiable trauma, dissociation, and P300 abnormalities. The impact of trauma seems to be robust in this study and future studies should assess trauma histories more carefully through a clinical history that includes assessment of childhood factors and a clinical interview that assesses whether the trauma achieves criteria A1 and A2.

While it is not clear if it impacted on the ability to find effects, the sample size of this study was relatively small, particularly when dividing the sample into three groups and using three predictors to predict ERP outcomes. A larger sample size would be valuable to confirm effects and to investigate other factors, such as early childhood history, which may influence the findings.

4.5. Summary and implications

The finding of this study indicates that PTSD may not play a central role in attention-related problems post trauma. Therefore, when studying attention after trauma, a non-trauma control group should be used as well as a measure of dissociation. Neither of these recommendations are currently in widespread use. There now seems to be sufficient evidence from a range of studies to indicate that trauma in and of itself may be the sources of many of the abnormalities often attributed to PTSD, particularly when careful controls are not used. Likewise, dissociative pathology with its known effects on fundamental sensory processing is likely to contribute significantly to attentional difficulties. Clearly, more attention to both of these factors is needed to get a complete picture of attentional disturbances post trauma.

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References

American Psychiatric Association, 2000. Diagnostic and Statistical Manual of Mental Disorders, 4th ed. American Psychiatric Association, Washington, DC. Text Revision.

Attias, J., Bleich, A., Gilat, S., 1996. Classification of veterans with post-traumatic stress disorder using visual brain evoked P3s to traumatic stimuli. British Journal of Psychiatry 168, 110–115.

Berlad, I., Pratt, H., 1995. P300 in response to the subject's own name. Electroencephalography and Clinical Neurophysiology. Evoked Potentials 96, 472–474.

Blackwood, D., 2000. P300, a state and trait marker in schizophrenia. Lancet 355, 771–772.

Bleich, A., Attias, J., Furman, V., 1996. Effect of repeated visual traumatic stimuli on the event related P3 brain potential in post-traumatic stress disorder. International Journal of Neuroscience 85, 45–55.

Bremner, J.D., Narayan, M., Staib, L.H., Southwick, S.M., McGlashan, T., Charney, D.S., 1999a. Neural correlates of memories of childhood sexual abuse in women with

and without posttraumatic stress disorder. American Journal of Psychiatry 156, 1787–1795.
Bremner, J.D., Narayan, M., Staib, L.H., Southwick, S.M., McGlashan, T., Charney, D.S., 1999b. Neural correlates of exposure to traumatic pictures and sound in Vietnam combat veterans with and without posttraumatic stress disorder: a positron emission tomography study. Biological Psychiatry 45, 806–816.
Buckley, T.C., Blanchard, E.B., Neill, W.T., 2000. Information processing and PTSD: a review of the empirical literature. Clinical Psychology Review 20, 1041–1065.
Carlson, E.B., Putnam, F.W., 1993. An update on the dissociative experiences scale. Dissociation: Progress in the Dissociative Disorders 6, 16–27.
Charles, G., Hansenne, M., Ansseua, M., Pitchot, W., Machowski, R., Schittecatte, M., Wilmotte, J., 1995. P300 in posttraumatic stress disorder. Neuropsychobiology 32, 72–74.
Donchin, E.C., Coles, M.G., 1998. Is the P300 component a manifestation of context updating? Behavioral and Brain Sciences 11, 357–427.
Dorahy, M.J., Huntjens, R.J.C., 2007. Memory and attentional processes in dissociative identity disorder: a review of the empirical literature. In: Vermetten, E., Dorahy, M., Spiegel, D. (Eds.), Traumatic Dissociation: Neurobiology and Treatment. American Psychiatric Publishing Inc, Washington, DC, pp. 55–75.
Felmingham, K.L., Bryant, R.A., Kendall, C., Gordon, E., 2002. Event-related potential dysfunction in posttraumatic stress disorder: the role of numbing. Psychiatry Research 109, 171–179.
Fleming, K., Bandy, C., Kimble, M., 2010. Decisions to shoot in a weapon identification task: The influence of cultural stereotypes and perceived threat on false positive errors. Social Neuroscience 5, 201–220.
Foa, E.B., Riggs, D.S., Dancu, C.V., Rothbaum, B.O., 1993. Reliability and validity of a brief instrument for assessing post-traumatic stress disorder. Journal of Traumatic Stress 6 (4), 459–473.
Friedman, D., Cycowicz, Y.M., Gaeta, H., 2001. The novelty P3: an event-related brain potential (ERP) sign of the brain's evaluation of novelty. Neuroscience and Behavioral Reviews 25, 355–373.
Goldstein, R.Z., Parvaz, M.A., Maloney, T., Alia-Klein, N., Woicik, P.A., Telang, F., Wang, G., Volkow, N.D., 2008. Compromised sensitivity to monetary reward in current cocaine users: an ERP study. Psychophysiology 45, 705–713.
Gray, H.M., Ambady, N., Lowenthal, W.T., Deldin, P., 2004. P300 as an index of attention to self-relevant stimuli. Journal of Experimental Social Psychology 40, 216–224.
Ilardi, S.S., Atchley, R.A., Enloe, A., Kwasny, K., Garratt, G., 2007. Disentangling attentional biases and attentional deficits in depression: an event-related potential P300 analysis. Cognitive Therapy and Research 31, 175–187.
Janoff-Bulman, R., 1992. Shattered Assumptions: Towards a New Psychology of Trauma. Free Press, New York.
Johnson, R., 1986. A triarchic model of P300 amplitude. Psychophysiology 23, 367–384.
Karl, A., Shaefer, M., Malta, L.S., Dorfel, D., Rohleder, N., Werner, A., 2006a. A meta-analysis of structural brain abnormalities in PTSD. Neuroscience and Biobehavioral Reviews 30, 1004–1031.
Karl, A., Malta, L.S., Maercker, A., 2006b. Meta-analytic review of event-related potential studies in post-traumatic stress disorder. Biological Psychology 71, 123–147.
Katayama, J., Polich, J., 1998. Stimulus context determines P3a and P3b. Psychophysiology 35, 23–33.
Kaufman, M.L., 2002. Dissociation status and attentional allocation in male Vietnam combat veterans with posttraumatic stress disorder. Dissertation Abstracts International: Section B: The Sciences and Engineering 63(1-B), 110.
Kimble, M.O., Kaloupek, D., Kaufman, M., Deldin, P., 2000. Stimulus novelty differentially affects attentional allocation in PTSD. Biological Psychiatry 47, 880–890.
Kimble, M.O., Kaufman, M., Kaloupek, D.G., Forti, A., 2001. Predictors of P3 amplitude in combat veterans with PTSD. Paper presented at the 17th Annual Meeting of the International Society of the International Society for Traumatic Stress Studies. New Orleans, LA.
Kimble, M.O., Frueh, B.C., Marks, L., 2009. Does the modified Stroop effect exist in PTSD? Evidence for the file drawer effect from dissertation abstracts. Journal of Anxiety Disorders 23, 650–655.
Kirino, E., 2006. P300 is attenuated during dissociated episodes. Journal of Nervous and Mental Disease 194, 83–90.
Kodama, E., Morita, K., Maeda, H., Nakamura, J., Kinoshita, S., Kawamura, N., Nakazawa, Y., 1996. Smoking motivation in normal subjects using event-related potentials. Human Psychopharmacology: Clinical and Experimental 11, 123–130.
Krystal, J.H., Bennet, A.L., Bremner, J.D., Charney, D.S., 1995. Toward a cognitive neuroscience of dissociation and altered memory functions in post-traumatic stress disorder. In: Friedman, M.J., Charney, D.S., Deutch, A.Y. (Eds.), Neurobiological and Clinical Consequences of Stress: From Normal Adaptation to PTSD. Lippincott-Raven Publishers, Philadelphia, PA, pp. 239–269.
Lanius, R.A., Bluhm, R., Lanius, U., Pain, C., 2006. A Review of Neuroimaging studies in PTSD: heterogeneity of response to symptom provocation. Journal of Psychiatric Research 40, 709–729.
McEwen, B.S., 2000. The neurobiology of stress: from serendipity to clinical relevance. Brain Research 886, 172–189.
McEwen, B., Lasley, E.N., 2007. Allostatic load: when protection gives way to damage. In: Monat, A., Lazarus, R.S., Reevy, G. (Eds.), The Praeger Handbook on Stress and Coping, vol. 1. Praeger Publishers/Greenwood Publishing Group, Westport, pp. 99–109.
McFarlane, A.C., Weber, D.L., Clark, C.R., 1993. Abnormal stimulus processing in posttraumatic stress disorder. Biological Psychiatry 34, 311–320.
Metzger, L.J., Orr, S.P., Lasko, N.B., Pitman, R.K., 1997. Auditory event-related potentials to tone stimuli in combat-related posttraumatic stress disorder. Biological Psychiatry 42, 1006–1015.
Metzger, L.J., Carson, M.A., Paulus, L.A., Lasko, N., Paige, S., Pitman, R.K., Orr, S., 2002. Event-related potentials to auditory stimuli in female Vietnam nurse veterans with posttraumatic stress disorder. Psychophysiology 39, 49–63.
Neylan, T.C., Jasiukaitis, P.A., Lenoci, M., Scott, J.C., Metzler, T.J., Weiss, D.S., Schoenfeld, F.B., Marmar, C.R., 2003. Temporal stability of auditory and visual event-related potentials in posttraumatic stress disorder. Biological Psychiatry 53, 216–225.
Nieuwenhuis, S., Cohen, J.D., Aston-Jones, G., 2005. Decision making, the P3, and the Locus Coeruleus-Norepinephrine System. Psychological Bulletin 131, 510–532.
Polich, J., 2007. Updating P300: an integrative theory of P3a and P3b. Clinical Neurophysiology 188, 2128–2148.
Polich, J., Kok, A., 1995. Cognitive and biological determinant of P300: an integrative review. Biological Psychology 41, 103–146.
Polich, J., Pollock, V.E., Bloom, F.E., 1994. Meta-analysis of P300 amplitude from males at risk of alcoholism. Psychological Bulletin 155, 55–73.
Schucard, J.L., McCabe, D.C., Szymanski, H., 2008. An event-related potential study of attention deficits in posttraumatic stress disorder during auditory and visual Go/Nogo continuous performance tasks. Biological Psychology 79, 223–233.
Semlitsch, H., Anderer, P., Schuster, P., Presslich, O., 1986. A solution for reliable and valid reduction of ocular artifacts, applied to the P300 ERP. Psychophysiology 23, 695–703.
Simons, R.F., Russo, K.R., 1987. Event-related potentials and continuous performance in subjects with physical anhedonia or perceptual aberrations. Journal of Psychophysiology 1, 401–410.
Stanford, M.S., Vasterling, J.J., Mathias, C.W., Constans, J.I., Houston, R.J., 2001. Impact on threat relevance on P3 event-related potentials in combat-related post- traumatic stress disorder. Psychiatry Research 102, 125–137.
Tabachnick, B.G., Fidell, L.S., 1989. Using Multivariate Statistics, 2nd ed. Harper Collins, New York.
Tedeschi, R.G., Calhoun, L.G., Cann, A., 2007. Evaluating resource gain: understanding and misunderstanding posttraumatic growth. Applied Psychology: An International Review 56, 396–406.
Vasterling, J.J., Duke, L.M., Brailey, K., Constans, J.I., Allain, A.N., Sutkey, P.B., 2002. Attention, learning, and memory performance and intellectual resources in Vietnam veterans: PTSD and no disorder comparisons. Neuropsychology 16, 5–14.
Vermetten, E., Spiegel, D., 2007. Perceptual processing and traumatic stress: contributions from hypnosis. In: Vermetten, E., Dorahy, M., Spiegel, D. (Eds.), Traumatic Dissociation: Neurobiology and Treatment. American Psychiatric Publishing Inc, Washington DC, pp. 103–118.
Vrana, S., Lauterbach, D., 1994. Prevalence of traumatic events and post-traumatic psychological symptoms in a nonclinical sample of college students. Journal of Traumatic Stress 7, 289–302.
Vythilingam, M., Heim, C., Newport, J., Miller, A.H., Anderson, E., Bronen, R., Brummer, M., Staib, L., Vermetten, E., Charney, D.S., Nemeroff, C.B., Brenmer, J.D., 2002. Childhood trauma associated with smaller hippocampal volume in women with major depression. American Journal of Psychiatry 150, 2072–2080.
Vythilingam, M., Luchenbaugh, D.A., Lam, T., Morgan, C.A., Lipschitz, D., Charney, D.S., Bremner, J.D., Southwick, S.M., 2005. Smaller head of the hippocampus in Gulf War-related posttraumatic stress disorder. Psychiatry Research: Neuroimaging 139, 89–99.
Yang-Wang, J., Polich, J., 2003. Meta-analysis of P300 and schizophrenia: patients, paradigms, and practical implications. Psychophysiology 40, 684–701.
Zoellner, T., Maercker, A., 2006. Posttraumatic growth in clinical psychology — a critical review and introduction of a two component model. Clinical Psychology Review 26, 626–653.