Information Processing of the Rorschach’s Traumatic Content Index in Trauma-exposed Adults: An Event Related Potential (ERP) Study

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ABSTRACT

PTSD elicits hypervigilance to trauma-related stimuli. Our novel research examined event-related potentials from Blood, Anatomy, and Morbid content derived from the Rorschach’s traumatic content index (TCI). Participants included: 16 with PTSD, 24 trauma-exposed without PTSD (non-PTSD), and 16 non-traumatized Controls. P3 oddball paradigms were used with TCI-derived Distractors and neutral Targets/Standards. We predicted larger P3 amplitudes in the context of TCI-related Distractors among trauma-exposed participants. Significant interaction of Group and Distractor type was found for P3 amplitude. PTSD and non-PTSD groups exhibited larger P3 amplitudes from Blood and Anatomy Distractors, and attenuated amplitudes from Morbid; the reverse pattern was found among Controls. A late negative component was observed, denoting a significantly larger area under the curve (AUC) among the PTSD group for Anatomy and Blood Distractors. Larger AUC’s were observed for Distractors among the PTSD group, and Targets among Controls. The findings concur with the neurocircuitry model of PTSD and suggest impairment in cerebral suppression of attention to stimuli that may have been perceptually primed with trauma.

1. Introduction

An exposure to a life-threatening event is sometimes followed by an elevation of psychological distress due to the development of such symptoms as intrusive memories, hyper-arousal, and avoidance of trauma-related stimuli. These post-traumatic stress (PTS) symptoms are usually followed by a feeling of constant threat to the individual’s well-being (Ehlers & Clark, 2000) and the perception of the environment as unstable and dangerous (Janoff-Bulman, 1989). In some cases, severe PTS symptom prevalence beyond one month may lead to the clinical diagnosis of a post-traumatic stress disorder (PTSD) (DSM-5, American Psychiatric Association, 2013).

1.1. ERP studies in PTSD

Event-related potential (ERP) studies have been used to compare information-processing patterns of individuals diagnosed with PTSD to healthy controls (Felmingham, Bryant, Kendall, & Gordon, 2002; Gallytly, Clarc, McFarlane, & Weber, 2001; McFarlane, Weber, & Clark, 1993). Among several ERP components, the P3, a centro-parietal positive component occurring around 300 ms after stimulus onset, has been widely used to examine trauma-related changes in attention (for review, see Javanbakht, Liberzon, Amirsadri, Gjini, & Boutros, 2011; Johnson, Allana, Medlin, Harris, & Karl, 2013). The P3 is commonly elicited by a three-stimuli oddball paradigm, in which the participants are requested to respond to a low frequency target stimulus presented amongst high frequency, repetitive standard stimuli and low frequency salient distractors they must ignore; the stimuli are referred to as Target, Standard, and Distractor stimuli. It has been previously reported that when individuals with PTSD are presented with an oddball paradigm that includes trauma-related Distractors, the P3 amplitude in response to Targets and Distractors (also known as P3b and P3a, respectively) is enhanced, while in the context of neutral (not trauma-related) Distractors, the response to either Target and Distractor stimuli is reduced (Karl, Malta, & Maercker, 2006; Javanbakht et al., 2011; Johnson et al., 2013). PTS symptom severity has also been associated with P3 amplitudes (Lobo et al., 2015). These findings suggest that, compared to healthy controls, individuals diagnosed with PTSD exhibit attentional alterations: allocating more attention to stimuli perceived to be threatening or trauma-related, while reducing attention to neutral
stimuli (Johnson et al., 2013; Karl et al., 2006). This pattern of cerebral response was conceptualized at the cognitive level by the “resource allocation” model of PTSD (Ehlers & Clark, 2000). According to this model, trauma facilitates the development of a “fear network”, leading to an attentional bias to trauma-related stimuli at the expense of neutral stimuli. These assertions also align with the “neurocircuitry” model of PTSD that associates PTSD-related information processing changes and interaction patterns of cerebral structures (Rauch, Shin, Whalen, & Pitman, 1998). According to this neurocognitive model, PTSD involves impaired prefrontal cortical (PFC) top-down regulation of hyper-responsivity within the amygdala, along with alterations in hippocampal activity that lead to deficits in contextual conditioning (Rauch, Shin, & Phelps, 2006). PFC deficit, particularly in the ventral/medial PFC, which is thought to impair suppression of attention to trauma-related stimuli, might be expressed by larger P3 amplitudes to trauma-related stimuli. Both models are supported by the clinical manifestation of PTSD that includes hypervigilance to trauma-related stimuli, exaggerated startle response and concentration difficulties (DSM-5, APA, 2013). Additionally, although most studies have reported on significant P3 differences between participants diagnosed with PTSD and either non-PTSD traumatized participants or Control subjects with no previous traumatic history (Johnson et al., 2013), recent research findings suggest that P3 alterations might be found among individuals with previous traumatic exposure even without meeting clinical criteria for PTSD diagnosis (Kimble, Fleming, Bandy, & Zambetti, 2010). Most conceptualizations of PTSD characterize the condition as hyper-responsivity to incoming stimuli that has been coupled with traumatic experience. However, the nature of these associations and the mechanism by which some inputs become “trauma-related stimuli” is still not clear. Previous research findings suggest that those with PTSD exhibit elevated cerebral responses to stimuli that are associated with their specific traumatic experience, such as combat- or earthquake-related stimuli, but not to trauma-irrelevant stimuli (Attias, Bliech, Furman, & Zinger, 1996a; Attias, Bliech, & Gilat, 1996b; Stanford, Vasterling, Mathias, Constans, & Houston, 2001; Zhang, Kong, Han, Najam Ul Hasan, & Chen, 2014; Chung, Kong, Hasan, Jackson, & Chen, 2015). Other authors have hypothesized that cognitive alterations related to PTSD are not limited to increased attention to specific trauma-associated stimuli but to a general increased expectancy of threat, resulting in elevated sensitivity to threat-related cues (Engelhard, de Jong, van den Hout, & van Overveld, 2009; Kimble et al., 2010). Though some research suggests that PTSD-related hypersensitivity to threat exists even at earlier, subliminal levels, this attentional bias to threat was postulated to mainly occur in later, post-recognition stages of information processing (Buckley, Blanchard, & Neill, 2000). The hypothesis of general sensitivity to threat is also supported by the expression of PTSD symptoms that frequently include a constant search for a wide variety of threats in the everyday environment, beyond those related to the original trauma. However, ERP studies that have used threatening stimuli not directly related to the participants’ traumatic experiences have found reduced threat processing, possibly due to an increased expectancy of threatening information or, alternatively, as an adaptive response aimed at reducing emotional arousal (Kimble, Batterink, Marks, Ross, & Fleming, 2012; MacNamara, Post, Kennedy, Rabinak, & Phan, 2013).

Some previous research, however, suggest that those with PTSD may possess a general sensitivity that is not limited to perceived threat. Research findings demonstrating greater PTSD-related cerebral responses to unpleasant/negative stimuli (not considered threatening or trauma-related) have caused some authors to suggest the existence of a PTSD-related hypervigilant pattern of information processing; such a pattern, they suggest, is characterized by an elevated response to negative emotional stimuli, regardless whether or whether not it contains threatening content (Blomhoff, Reinvang, & Malt, 1998; Lobo et al., 2014; Saar-Aschenazy et al., 2015). However, valence effects were also found in ERP studies among participants with no trauma history, and have been associated with selective attention to negative stimuli; this has been postulated to represent a general “negativity bias” among the general population (Olofsson, Nordin, Sequeira, & Polich, 2008). Therefore, it is not clear whether this increase in cerebral response to negative stimuli can be attributed solely to PTSD.

A common denominator of previous hypotheses is that patients with PTSD may be hypervigilant to the conceptual aspects of threatening stimuli, in which association with the traumatic event is achieved via meaning (for example, when a rape victim encounters the word “helplessness”). An alternative approach suggests that trauma-exposed participants may be highly responsive to the perceptual properties of stimuli (Ehlers et al., 2002), in which an association between stimuli and the traumatic event is made through perceptual priming (for example, seeing headlights leads to accelerated heart rate because they were previously encountered during a nighttime head-on collision). The perceptual priming approach postulates that the traumatic experience leads to data-driven processing (i.e. focusing on the perceptual and sensory impression of an event rather than on its meaning). This results in a strong perceptual priming of the various stimuli encountered in temporal proximity to the traumatic experience (Christianson, 1992; Halligan, Clark, & Ehlers, 2002; Kindt, van den Hout, Arntz, & Drost, 2008; Van der Kolk & van der Hart, 1989; Wing Lun, 2008). These primed stimuli, when identified in the everyday environment, are then perceived as a warning signal of impending danger and may lead to a rapid, vivid recollection of the traumatic event, experienced as a “flashbacks.” This approach is supported by behavioral research studies which indicate that, in comparison to the general population, traumatized individuals who develop PTSD symptoms are more likely to associate stimuli characterized by salient perceptual properties with trauma-related information (Halligan et al., 2002; Kindt et al., 2008; Lin, Hofmann, Qian, & Li, 2015). Accordingly, war veterans with PTSD have been found to demonstrate heightened physiologic arousal, expressed by higher skin conductance and elevated heart rate, when perceiving Rorschach Inkblots as being related to autobiographical images of combat trauma. The authors postulated that this heightened physiologic arousal to the Rorschach inkblots corresponds to the development of intrusive symptoms that occur when encountering a stimulus with perceptual similarity to those encountered at the time of trauma (Goldfinger, Amdur, & Liberson, 1998). Since the Rorschach is considered primarily a perception test (Blatt, 1990), this finding suggests that perceptual properties of inkblots may trigger a conditioned response mediated by altered information processing patterns.

In summary, current cognitive and neurocircuitry models suggest that PTSD involves directing more attention to stimuli that were previously associated with traumatic experience. This was believed by some authors to reflect a deficit in PFC top-down regulation of hyper-reactivity within the amygdala to trauma-related stimuli (Rauch, Shin, et al., 1998, Rauch, Shin, & Phelps, 2006). ERP research demonstrating larger P3 amplitudes to trauma-related stimuli among individuals with PTSD supports this theory. While some authors have suggested that the association between incoming stimuli and traumatic experience is achieved via meaning (through direct association with a specific traumatic experience) or via other conceptual properties of the stimuli (level of threat or level of negativity), others have suggested that the association of stimuli with the traumatic event is made through perceptual priming.

1.2. The Rorschach inkblot test and PTSD

The Rorschach is a psychological test intended for evaluation of perception along with cognitive function and personality characteristics (Blatt, 1990; Exner, 2001). The Rorschach examines the individual’s perception of 10 inkblots printed on cards, and is widely used by clinical psychologists for assessment and intervention planning (Weiner & Greene, 2007). Exner (1974) developed a comprehensive system for analyzing responses to the Rorschach test, currently the most frequently used method.
for applying the Rorschach in research and clinical practice. An accumulating body of empirical evidence derived from research in recent years suggests the Rorschach is a valid tool for the assessment of the traumatic experience, and can provide valuable information regarding traumatic imagery and cognitive avoidance strategies among trauma-exposed individuals (Brand, Armstrong, & Loewenstein, 2006; Brand, Armstrong, Loewenstein, & McNary, 2009; Holaday, 2000; Katsounari & Jacobowitz, 2011; Opas & Hartmann, 2013; Sloan, Arsenault, & Hilsenroth, 2002; Tibon, Rothschild, Appel, & Zeligman, 2011; Viglione, Towns, & Lindshield, 2012).

Based on Exner’s comprehensive system, the analysis of the individual’s set of responses (the individual’s “protocol”) on the Rorschach provides several indicators of mental function. Some of these indices are specifically associated with PTSD, including those that tap into proneness to psychopathology, hypervigilant processing style, thought disturbances and impairment in stress tolerance (Tibon et al., 2011; Viglione et al., 2012). Among these indices, the traumatic content index (TCI) is a constellation of several themes more frequently reported in Rorschach protocols of individuals diagnosed with PTSD, and are considered related to personal traumatic history (Armstrong & Loewenstein, 1990). The TCI consists of the number of Rorschach responses in which an individual identifies inkblot percepts as relating to one of following thematic categories: 1) blood (Blood), 2) internal organs such as liver, bones or intestines (Anatomy), 3) sexual organs or sexual acts and behaviors (Sex), 4) objects described as torn, broken, ruined, dead or attributed with dysphoric feeling (Morbid) and 5) aggressive acts (Aggressive Movement). The TCI is calculated by the sum of TCI responses divided by the total number of responses in a Rorschach protocol (Tibon et al., 2011).

Over the past 25 years, an extensive body of research has shown that, compared to individuals with no traumatic history, the Rorschach protocols of participants who report diverse interpersonal and non-interpersonal traumatic experiences are characterized by elevated frequency of the five themes of the TCI (Armstrong & Loewenstein, 1990; Burch, 1993; Goldfinger et al., 1998; Kamphuis, Kugeares, & Finn, 2000; Min, Lee, Kim, & Sim, 2011; Opas & Hartmann, 2013; Smith, Chang, Kochinski, Patz, & Nowinski, 2010; Sloan, Arsenault, Hilsenroth, Handler, & Harvill, 1996; Van der Kolk & Ducey, 1989; for review see Viglione et al., 2012). It has been suggested that the ambiguous nature of the Rorschach promotes the breakthrough to consciousness of traumatic imagery. According to this idea, the appearance of traumatic content in the individual’s response reflects perception of the inkblot as related to specific themes associated with their traumatic experience through meaning (Viglione et al., 2012). For example, a response indicating perception of Blood content may be related to a previous trauma by being a likely symbol of danger and injury to the human body experienced at the traumatic situation, while a response indicating Morbid content such as “rotten apple” may represent a sense of damaged or injured self-esteem and feeling of incompleteness related to the traumatic event (Meloy & Genoco, 1997; Viglione et al., 2012). However, the high frequency with which TCI related themes are reported on Rorschach protocols by individuals with PTSD may be explained in other ways than trauma-related association; for example, Morbid responses can indicate, according to Rorschach conceptualization, negative feelings toward oneself that may stem from general feelings of inadequacy and blame, or even be a reaction to being tested in a psychological setting.

1.3. This study

This study proposed to examine the electrophysiological response of trauma-exposed participants to an oddball paradigm in which Distactor stimuli consisted of two-word phrases derived from the TCI (Armstrong & Loewenstein, 1990). Target and Standard stimuli were comprised of two-word neutral phrases derived from neutral content categories of the Rorschach. While it has been postulated that the identification of a Rorschach inkblot with traumatic content represents an activation of traumatic imagery via semantic or meaning-based associations (Viglione et al., 2012), the neural correlates of such processes have never been explored by ERP analysis. The advantage of utilizing ERP, in contrast to other neuroimaging techniques such as fMRI and PET, is its ability to provide excellent time resolution especially suitable for examining rapid processing of potentially threatening stimuli (LeDoux, 2000).

The neurocircuity model proposes that PTSD is associated with an impaired PFC suppression of attention to trauma-related stimuli (Rauch et al., 2006). This understanding is supported by ERP research indicating an attentional bias toward threat/trauma-related stimuli resulting in larger P3 amplitudes. If TCI-related contents indeed facilitate activation of traumatic imagery, as was previously suggested (Viglione et al., 2012), then the exposure of participants with trauma history to such contents would result in P3 alteration. Consequently, we hypothesized that:

1. Compared to non-traumatized Controls, participants with PTSD would exhibit larger P3 amplitudes in the context of TCI-related Distactors.
2. Exposure to TCI-related content would be followed by increased P3 amplitudes in both the trauma-exposed groups (PTSD and non-PTSD), compared to healthy control participants.
3. When exposed to TCI-related contents, participants with previous traumatic exposure would exhibit increased P3 amplitudes only in response to Target and Distactor stimuli. If such hypothesis were to be confirmed, it may suggest the existence of increased cerebral reactivity to either target realted/trauma related stimuli among trauma-exposed participants, along with intact ability to discard non-relevant (Standard) stimuli.

In addition to the formal hypotheses delineated above, we also considered the potential effects of TCI categories on responsivity. Since the TCI consists of five distinct content categories, it is possible that Distactors from various categories of the TCI facilitate different cerebral responses. Accordingly, the current study examined participant cerebral response by using three oddball paradigms, each containing Distactors from only one of the Anatomy, Blood, and Morbid TCI categories. Due to the novelty of the current research, we had no preliminary hypothesis regarding the nature of cerebral response associated with each of the TCI categories; however, by using this experimental design, we intended that the current study not only shed light on potential mechanisms by which TCI-related stimuli affects information processing, but also whether this mechanism differs in response to various TCI categories.

2. Materials and methods

2.1. Participants

Overall, the total sample consisted of 56 participants (mean age = 24.20; SD = 2.39). Trauma-exposed participants were recruited through local university advertisement boards and flyers posted at the university’s student counseling center and various local medical centers, requesting individuals who have experienced severe negative life events to participate in our study. Forty participants (26 females) reported a previous traumatic history that included at least one traumatic event in accordance with DSM-5 “criterion A” for PTSD diagnosis (APA, 2013). These participants were divided into two groups. The first group, the “PTSD” group, consisted of 16 participants (12 females) who met clinical criteria for PTSD and had scores of at least 40 or greater on the Clinician Administered PTSD Scale (CAPS) (mean = 50.67; SD = 9.53); a CAPS score of 40 and greater is postulated to indicate moderate to severe PTSD symptoms (MacNamara et al., 2013). The second group, the “non-PTSD” group, included 24 participants (14 females) that had been exposed to one or more trauma-related events, but did not meet clinical criteria for the diagnosis of PTSD at the time of testing. The average CAPS score for
21 subjects of this group (mean = 26.00; SD = 9.92) showed subthresh- 
hold PTSD (Weathers, Keane, & Davidson, 2001); three additional sub-
jects with no CAPS score were included in this group based on their PDS 
(Posttraumatic Diagnostic Scale) score that indicated a subthreshold, 
mild level of PTSD. The average PDS score (mean = 10.21; SD = 7.11) 
for all 24 “non-PTSD” participants indicated a subthreshold, mild PTSD 
(McCarthy, 2008).

The Control group consisted of 16 university students (14 females), 
recruited through local university advertisements, with no previous 
traumatic history. None of the participants reported any medical 
problems, being in psychological or psychiatric treatment or the use 
of any medication. All participants provided signed informed consent 
and were compensated for their time. The study was approved by the 
university ethics committee.

2.2. Measures and procedures

All questionnaire administration and interviews were performed by 
a licensed clinical psychologist who was trained to evaluate PTSD 
symptoms.

2.2.1. Trauma History Questionnaire (THQ)

The THQ is a 24-item self-report questionnaire developed to 
measure exposure to potentially traumatic events included in the “A1 
criteria” of DSM-IV for PTSD and acute stress disorder (Hooper, 
Stockton, Krupnick, & Green, 2011). The events may include crime-
related events (e.g. robbery, mugging), general disaster and trauma 
(e.g. injury, natural disaster, witnessing death), and unwanted physical 
and sexual experiences. For each of the items, the participant indicates 
whether or not he or she experienced the event, and if so, the number of 
times and approximate age(s) of occurrence. The THQ has been widely 
used to measure previous traumatic history among clinical (PTSD) and 
non-clinical (non-PTSD) samples. Moderate to high test-retest reliability 
and validity have been reported (Hooper et al., 2011). In the current 
study, a trauma history score was calculated by adding the number of 
traumatic events reported by the participant. Thus, a higher score 
indicates a higher rate of traumatic event exposure. This measure was 
administered to all the participants in the study.

2.2.2. Postraumatic Diagnostic Scale (PDS)

The PDS is a 49-item self-rating scale developed to assess PTSD 
diagnosis according to DSM-IV criteria (Foa, 1995). The first section of 
the questionnaire includes a short checklist that identifies potentially 
traumatizing events experienced by the respondent. Next, in the case of 
more than one traumatic experience, the participant is asked to choose 
one single traumatic experience “that currently bothers you the most” 
(major event). Then, with regard to the major event, the participant is 
asked to use a 4-point scale to rate the frequency with which he or she 
has experienced each one of 17 PTSD symptoms over the previous two 
weeks; the 17 items measure thought intrusion (re-experiencing), 
avoidance and arousal symptoms. Finally, a PTSD symptom severity 
score is calculated; a cutoff score of 11 and above has been suggested to 
reflect a moderate level of PTSD (McCarthy, 2008). Previous research 
findings have demonstrated high internal consistency and test-retest 
reliability as well as a satisfactory agreement with PTSD-related 
diagnostic interviews such as the Structural Clinical Interview for 
DSM Disorders - SCID (Foa, Cashman, Jaycox, & Perry, 1997). This 
measure was administered to all the participants in the study.

2.2.3. Clinician-Administered PTSD Scale (CAPS)

The CAPS is a semi-structured interview for PTSD diagnosis 
according to DSM-IV criteria (Blake et al., 1995). The CAPS is consid-
ered a “gold standard” in PTSD assessment. It provides informa-
tion regarding the intensity and frequency of PTSD symptoms in 
response to traumatic experience. A total severity score is calculated 
by adding the intensity and frequency scores of 17 4-point scale items 
that relate to one of three subscales: intrusion (re-experiencing), 
avoidance and numbing, and hyper-arousal. The CAPS has demon-
strated high reliability and validity ratings across various studies (Pupo 
et al., 2011; Weathers et al., 2001). This measure was administered only 
in the trauma-exposed groups (PTSD and non-PTSD).

2.2.4. Beck Depression Inventory-II (BDI-II)

The BDI-II is a 21-item self-report measure assessing cognitive, 
affective and behavioral outcomes of depression (BDI-II, Beck, 
Steer, & Brown, 1996). The BDI is widely used and has high reliability 
and validity as a measure of depression (Beck et al., 1996). This 
measure was administered to all the participants in the study.

2.2.5. Other medical or psychological/psychiatric conditions

Finally, participants from all groups (PTSD, non-PTSD and Control) 
were asked whether they suffer from any major health problems, were 
taking prescribed medication (including psychiatric medication) or 
were receiving psychotherapy.

2.3. Oddball paradigm with Rorschach's traumatic content index

Distractors

All participants’ brain activity was recorded via EEG while perform-
ing these paradigms. The oddball paradigms used in this study 
contained 250 two-word phrases of visual stimuli of three Trial 
Types: 1) Target stimuli consisting of a specific neutral phrase (e.g. 
“silver fish”) that related to Rorschach's Animal content category; these 
stimuli appeared 50 times (20% of all stimuli shown in the task), 
presented randomly, and participants were asked to press a joystick 
button when detecting such a phrase; 2) Distractor stimuli consisting of 
10 different phrases related to three of Exner’s content categories 
included in the TCI (Anatomy, Blood, or Morbid); each phrase was 
repeated five times resulting in 50 phrases (20% of all stimuli) 
presented randomly; and 3) Standard (non-target) stimuli consisting 
of 30 different phrases of domestic items related to Rorschach’s 
Household content category (Exner, 2001), such as “desk lamp”, “wall 
clock” or “kitchen cupboard”; each phrase was repeated five times, 
resulting in 150 phrases presented randomly (60% of all stimuli).

Each participant was presented with three experimental paradigms 
that were identical except for the type of Distractor stimuli: Anatomy, 
Blood, and Morbid. Since each TCI content category may have a 
different effect on cerebral response, the experimental design included 
three runs, each employing Distractors from a different TCI category. 
The Anatomy paradigm included Distractors that were comprised of 
phrases related to skeletal, muscular, and internal anatomy such as 
“two lungs”, “pair of ribs”, or “brain tissue.” The Blood paradigm 
included Distractors that were comprised of phrases related to blood 
content such as “red blood”, “fresh blood”, or “a pond of blood.” The 
Morbid paradigm included Distractors that were comprised of phrases 
related to dead objects (“a baby’s body”), destroyed, ruined, spoiled, 
damaged or broken objects (“broken toy”) or objects attributed with a 
dysphoric feeling (“depressed woman”). The content category classi-
fication for the phrases used as stimuli was evaluated separately by two 
licensed clinical psychologists trained in Exner’s comprehensive system 
of Rorschach scoring; inter-rater reliability was high (Kappa = 0.90). 
Fig. 1 presents the experimental paradigm. At this study, we used three 
paradigms, each relating to different TCI content category (Anatomy/ 
Blood/Morbid), though the TCI contains five content categories. 
Distractors from the two additional content categories (Sex and 
Aggressive movement) were not used mainly due to time considera-
tions; each paradigm took as long as eight minutes and we estimated 
the using the all five categories would reduce the participant interest 
and motivation in completing the task.

2.3.1. Distractors: evaluating emotional valence and threat level

Since PTSD has previously been associated with increased respon-
sivity to negative emotional stimuli (Blomhoff et al., 1998; Saar-Ashkenazy et al., 2015) as well as increased responsivity to threatening stimuli (Engelhard et al., 2009; Kimble et al., 2012), we evaluated: 1) the emotional valence of the Distractor stimuli used in this study and 2) the perceived level of threat of Distractors in this study.

In order to evaluate the emotional valence of the Distractor stimuli, a separate group of 49 age-matched undergraduate students who did not participate in the ERP portion of the study (46 females, mean age = 22) were asked to rate Distractor phrases on a nine-point Likert scale from 1 (“exceptionally negative”) to 9 (“exceptionally positive”). Participants’ responses were analyzed with a repeated measure analysis of variance (ANOVA) with three content categories (Anatomy, Blood, Morbid) containing 10 phrases in each category (3 × 10). The results indicated significantly different negative ratings by content category, $F(2, 26) = 240.36, p < .00$, $\eta^2_p = 0.91$. Bonferroni post hoc tests revealed that phrases in the Morbid category were perceived as significantly more negative ($M = 2.58, SE = 0.05$) than phrases from the Anatomy ($M = 3.98, SE = 0.07$) and Blood ($M = 3.35, SE = 0.09$) categories. Significant differences were also found between the Blood and Anatomy categories, $p < .00$, denoting that anatomy Distractors were perceived as more negative than Distractors in the Blood category.

In order to evaluate the perceived level of threat of Distractor stimuli, an additional 24 age-matched undergraduates students who did not participate in the ERP procedure (23 females, mean age = 22) were asked to rate the Distractor phrases on a 6-point Likert scale from 0 (“not threatening”) to 5 (“very threatening”). Participant responses were analyzed with a repeated measure analysis of variance (ANOVA) with three content categories (Anatomy, Blood, Morbid) containing 10 phrases in each category (3 × 10). The results indicated significantly different threat ratings by content category, $F(2, 22) = 17.30, p < .00$, $\eta^2_p = 0.61$. Bonferroni post hoc tests revealed that Blood ($M = 3.19, SE = 0.19$) and Morbid ($M = 3.15, SE = 0.11$) Distractors were rated as significantly more threatening than Anatomy Distractors ($M = 2.07, SE = 0.17$). No significant differences were found between Blood and Morbid Distractors.

Target, Standard, and Distractor stimuli were presented in random order. The order of the three experimental paradigms (Anatomy, Blood, and Morbid) was counterbalanced across participants. Chi-square analysis indicated no significant group differences in paradigm presentation order, $\chi^2(4, 56) = 0.64, p > .05$. Stimuli were presented as white letters on a black background computer screen. Times New Roman font size 88 letters were used. Each stimulus duration was 300 ms and interstimulus fixed intervals were 1700 ms, thus, stimuli were presented every 2 s.

Participants were seated in a comfortable armchair, told that they would see all kinds of phrases on the computer monitor and were asked to press a button on a joystick when they identified the Target stimuli (“silver fish”). The computer monitor was located 100 cm from the participant’s head.

2.4. Electrophysiological testing and measures

The EEG was recorded in a room free of noise and electromagnetic fields. Continuous EEG was recorded using a Micromed SD 64 channel system and a Neuroscan 64 channel elastic cap with electrode locations based on the 10/20 system. All electrodes were referenced to an electrode located at the tip of the nose. A ground electrode was placed on the right mastoid. A vertical electrooculogram (EOG) was recorded using two electrodes, one located above and one below the right eye. The impedance measure for each electrode was always below 5 kΩ. Raw data were continuously recorded with a 16-bit A/D and a band pass filter of 0.15–463 Hz and a sampling rate of 1024 Hz.

All data were analyzed using BPM software (Brain Performance Measurement: Orgil Medical Equipment, Inc.). EEG Recordings were segmented into time intervals that were time-locked to the stimuli, and extended from 200 ms pre-stimulus to 2000 ms post-stimulus. An eye movement correction procedure was performed offline using an eye movement correction algorithm. The algorithm detects an epoch with ocular artifacts by comparing the signals recorded from above and below the eye. In a second step, a correction is performed for each record and each channel separately. Additionally, EEG signals were visually scored on a high resolution computer monitor, and portions of the data containing eye movement, muscle movement or other sources of artifact were removed. Baseline correction for each trial was performed using the 200 ms prior to stimulus onset for each channel separately. Amplitude rejection had been applied to the data prior to averaging. Results with amplitude higher than 250 microvolts (even in a single channel) were excluded. For each participant, all trials were averaged per stimulus type (Target, Distractor, and Standard). In the final stage of averaging, the data were filtered using a 6 Hz low-pass filter.

Global field power (GFP) was calculated across all 12 electrodes, Groups (PTSD, non-PTSD, Control), Paradigm type (Anatomy, Blood,
served as an estimate for e
defect at mid-latency time intervals and a second, negative component (LNC). The P3 component was quantified in terms of peak amplitudes (maximum positive amplitude from baseline in microvolts) and latency (time interval from stimulus onset to peak amplitude in milliseconds) between 300 and 750 ms. The second component was evident between 950 and 1500 ms with no defined peak. Thus, we calculated the area under the curve (AUC) (Luck, 2014) by advancing along the time axes between the two time points (1 ms differentiates each successive sampling at a sampling rate of 1 KHz). The AUC is defined by the area between the curve and a baseline level, which was calculated by using the more positive amplitude of two time points (950 and 1500 ms). The AUC measurement, expressed in \( \mu \text{V} \times \text{ms} \) units, has been associated with total activity of the underlying neural substrate (Pratt, Mittelman, Bleich, & Laufer, 2004). Fig. 2 presents the GFP. The GFP, derived from the mean square, produced positive values for both positive and negative components. Thus, although the GFP values for the second component were positive, it is presented in its initial negative format.

2.5. Statistical analysis

Analyses were conducted by using SPSS version 21 (Armonk, N.Y.: IBM Corp., 2013). For comparison of demographics and behavioral assessment measures (THQ, PDS, BDI) one-way analysis of variance (ANOVA) with Group (PTSD, non-PTSD, Controls) as an independent variable was used. An independent t-test was used to track group differences (PTSD vs non-PTSD) on the CAPS assessment. A non-parametric Chi-square test was conducted to compare gender differences among the three groups.

P3 amplitude and latency as well as AUC comparisons were conducted by a repeated measure analysis of variance (ANOVA) with Group (PTSD, non-PTSD, Control) as a between-factor and Paradigm type (Anatomy, Blood, Morbid) X Trial type (Target, Distractor, Standard) X Electrode Midline site (Prefrontal, Frontal, Central, Parietal) X Electrode Side site (Left, Midline, Right) as within-factors. Greenhouse Geisser corrections were applied as necessary for violations of sphericity, and partial eta square \( (\eta^2_p) \) served as an estimate for effect size of the ANOVA’s. Bonferroni post hoc tests have been used to examine group differences, while contrast analysis was used to examine interaction effects for the P3 component analysis. Data were obtained from 12 electrodes (PF1, PFz, PF2, F3, Fz, F4, C3, Cz, C4, P3, Pz, P4) that were divided between two location factors. Given that the P3 response of different locations may represent divergent cognitive processes (Katayama & Polich, 1998), we assigned each electrode to a four-level Midline Site factor denoting Prefrontal (PF1, PFZ, PF2), Frontal (F3, Fz, F4), Central (C3, Cz, C4) and Parietal (P3, Pz, P4) Sites. Additionally, since the oddball paradigms used in this study included two-word phrases, and based on a well-established concept that the left hemisphere is associated with more efficient processing of verbal information (Dickson & Federman, 2014; Selpien et al., 2015), electrodes were also divided into a three-level Side Site factor denoting Left (PF1, F3, C3, P3), Middle (PFz, Fz, Cz, Pz) and Right (PF2, F4, C4, P4) sites. This categorization of the electrodes into two factors is in accordance with previous research (Kimble, Kalooupak, Kaufman, & Deldin, 2000).

All analyses were performed with and without gender and depression levels as covariates. Gender was selected as a covariate factor since numerous studies have reported that females are more likely to develop intense PTS symptoms, as well as meet criteria for PTSD (for review, see Tolin & Foa, 2006). Depression was selected as a covariate factor since comorbidity between PTSD and major depressive disorder is common (Stander, Thomsen, & Highfi1l-McRoy, 2014) and lower P3 amplitudes have been reported among depressed individuals (Lv, Zhao, Gong, Chen, & Miao, 2010). In all analyses, no significant effects for either of the covariates were found. Therefore, results are reported only for analyses with no covariates.

3. Results

3.1. Participant characteristics

No significant gender differences were found between groups, \( \chi^2(2, N = 56) = 4.14, p > .05 \), in spite of female predominance. No significant group differences in age were found. On the PDS, the majority of the participants in trauma-exposed groups (PTSD and non-PTSD) reported motor vehicle accidents (62.5%) as their major traumatic experience, 12.5% war or combat related traumatic experiences, 5.0% sexual assaults and 5.0% the loss of a family member. Most participants described a history of multiple types of trauma. The distribution of types of “main traumatic event” as well as types of overall traumatic event distribution, as reported on the PDS, is presented in Table 1. No significant statistical differences were found in the distribution of the main traumatic event type between the PTSD and non-PTSD groups, \( \chi^2(6, N = 40) = 4.47, p > .05 \).

Data for age, THQ, PDS, and BDI indices are presented in Table 2. A significant effect of Group on the level of previous traumatic exposure in the THQ was found. Bonferroni post hoc tests revealed significantly higher rates of previous traumatic exposure among participants in the PTSD and non-PTSD groups. No significant difference in trauma history levels between PTSD and non-PTSD groups, as reported at the THQ, was observed. A significant effect of Group on the level of post-traumatic symptoms, as indicated by the PDS, was found. As expected, Bonferroni post hoc tests have indicated that, in comparison to the Control group who reported no traumatic symptoms, PTSD and non-PTSD group participants reported significantly higher levels of traumatic symptoms.

<table>
<thead>
<tr>
<th>Trauma type</th>
<th>Major traumatic event</th>
<th>Any traumatic event</th>
</tr>
</thead>
<tbody>
<tr>
<td>Motor vehicle accident</td>
<td>25 (62.5%)</td>
<td>26 (65%)</td>
</tr>
<tr>
<td>War- or combat-related experience</td>
<td>5 (12.5%)</td>
<td>17 (42.5%)</td>
</tr>
<tr>
<td>Sexual assault</td>
<td>2 (5%)</td>
<td>5 (12.5%)</td>
</tr>
<tr>
<td>Loss of family member</td>
<td>2 (5%)</td>
<td>3 (7.5%)</td>
</tr>
<tr>
<td>Other</td>
<td>6 (15%)</td>
<td>19 (47%)</td>
</tr>
</tbody>
</table>

Note: Trauma type distribution as reported at the posttraumatic diagnostic scale (PDS).
In accordance with PDS norms (McCarthy, 2008) the levels of traumatic symptoms matched “mild” and “moderate to severe” levels of traumatic symptoms among the non-PTSD and PTSD groups, respectively. The difference in the level of traumatic symptoms reported by the PTSD and the non-PTSD groups was also statistically significant, indicating a higher level of traumatic symptoms among the PTSD group. Additionally, a significant difference in reported levels of depression, as indicated by the BDI, was found, with higher levels of depressive symptoms reported among those with PTSD, as compared to non-PTSD and Control participants. Nevertheless, the average score of each group indicated non-depression (BDI score < 13) (Beck et al., 1996, Dozois, Dobson, & Ahnberg, 1998; Kendall, Hollon, Beck, Hamenn, & Ingram, 1987; Whisman & Richardson, 2015).

3.2. ERP component analysis

3.2.1. P3 amplitude and latency

The grand averages of the ERP waveforms can be seen in Fig. 3 for Target stimuli and Fig. 4 for Distractor and Standard stimuli. Visual inspection of the waveforms suggests that, across trials, the trauma-exposed groups (PTSD and non-PTSD) were characterized by larger P3 amplitudes for the Anatomy and Blood paradigms compared to the Morbid paradigm, while the Control group was characterized by larger P3 amplitudes for the Morbid paradigm compared to the Anatomy and Blood paradigms. The results of the analysis of P3 amplitude and latency are provided below.

3.2.1.1. P3 amplitude

A Group (PTSD, non-PTSD, Control) X Paradigm Type (Anatomy, Blood, Morbid) X Trial Type (Target, Distractor, Standard) X Electrode Midline Site (Prefrontal, Frontal, Central, Parietal) X Electrode Side Site (Left, Middle, Right) repeated measures ANOVA was conducted in order to assess P3 peak amplitude levels.

Results indicated a significant Group X Paradigm Type crossover interaction, $F(3.43, 91.11) = 3.19, p < .05, \eta_p^2 = 0.11$. A secondary contrast analysis revealed that the combined effect of Group and Paradigm Type was significantly different for the Anatomy and Blood paradigms, compared to the Morbid paradigm, $F(2, 53) = 5.22, p < .01, \eta_p^2 = 0.17$; $F(2, 53) = 3.59, p < .05, \eta_p^2 = 0.12$, respectively. This points out differences in cerebral activation patterns in response to the various paradigms between study groups: participants in the PTSD and non-PTSD groups exhibited higher P3 amplitudes for the Anatomy and the

<table>
<thead>
<tr>
<th>Control</th>
<th>non-PTSD</th>
<th>PTSD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean (SD)</td>
<td>Mean (SD)</td>
<td>Mean (SD)</td>
</tr>
<tr>
<td>Age</td>
<td>23 (1.96)</td>
<td>24.63 (2.48)</td>
</tr>
<tr>
<td>THQ scores</td>
<td>0 (0)</td>
<td>5.00 (1.87)</td>
</tr>
<tr>
<td>PDS scores</td>
<td>0 (0)</td>
<td>10.21 (7.11)</td>
</tr>
<tr>
<td>Total CAPS scores</td>
<td>26 (9.92)</td>
<td>50.75 (9.22)</td>
</tr>
<tr>
<td>BDI scores</td>
<td>1.07 (1.38)</td>
<td>6.75 (7.9)</td>
</tr>
<tr>
<td>n</td>
<td>15</td>
<td>16</td>
</tr>
<tr>
<td>F/t</td>
<td>ns</td>
<td>40.59 &lt; .01</td>
</tr>
</tbody>
</table>

Note: THQ = Trauma History Questionnaire, PDS = Posttraumatic Diagnostic Scale, CAPS = Clinician Administered PTSD Scale, BDI = Beck Depression Inventory.

Fig. 3. Grand average ERPs for electrodes Fz and Cz in response to Target stimuli across the three experimental paradigms (Anatomy, Blood, Morbid) among the three study groups (PTSD, non-PTSD, Control). Shaded areas correspond to the time window for P3 (300–750 ms) and late negative component (LNC) (950–1500 ms).
Blood paradigms, in comparison to the Morbid paradigm. In contrast, Control participants exhibited lower amplitudes for the Anatomy and Blood paradigms in comparison to the Morbid paradigm. Fig. 5 illustrates this disordinal interaction pattern between Group and Paradigm Type on P3 amplitude across Trial Type (Target, Distractor, Standard), averaged for all 12 electrodes. No other significant main effects or interactions involving the Group factor were found. Table 3 displays the group averages for the P3 analysis.

A significant main effect of Trial Type was found, $F(1.54, 81.91) = 58.13, p < .01, \eta^2_p = 0.52$. Follow-up Bonferroni post hoc tests revealed a significant difference in amplitudes elicited by Target stimuli ($M = 10.82, SE = 0.65$) in comparison to Distractor ($M = 6.40, SE = 0.43, p < .00$) and Standard stimuli ($M = 5.40, SE = 0.42; p < .00$). The difference between amplitudes elicited by Distractor and Standard stimuli was also significant, $p < .05$.

Additionally, a significant effect of Electrode Side Site was found, $F(1.40, 74.63) = 34.34, p < .00, \eta^2_p = 0.39$. Bonferroni post hoc testing revealed a significant difference in amplitudes elicited by electrodes at the Left ($M = 7.79, SE = 0.43$) in comparison to the Right ($M = 7.14, SE = 0.39, p < .00$). No other significant main effects were found for peak amplitude.

3.2.1.2. P3 latency. A Group (PTSD, non-PTSD, Control) X Paradigm Type (Anatomy, Blood, Morbid) X Trial type (Target, Distractor, Standard) X Electrode Midline Site (Prefrontal, Frontal, Central, Parietal) X Electrode Side Site (Left, Middle, Right) repeated measures ANOVA was conducted in order to assess differences in P3 peak latencies.

A significant main effect for Midline Site was observed, $F(1.65, 87.47) = 10.35, p < .01, \eta^2_p = 0.16$. Bonferroni post hoc tests have
indicated that this effect was due to significantly longer latencies at Prefrontal sites ($M = 495.32, SE = 6.70$) in comparison to Frontal ($M = 483.97, SE = 6.78, p < .01$), Central ($M = 481.93, SE = 6.64, p < .01$) and Parietal ($M = 481.55, SE = 6.43, p < .05$) Sites. No other significant effects of Paradigm Type, Trial Type, or Electrode Side Site on latency time were observed.

### 3.2.2. Late negative component (LNC) AUC

A Group (PTSD, non-PTSD, Control) X Paradigm Type (Anatomy, Blood, Morbid) X Trial type (Target, Distractor, Standard) X Electrode Midline Site (Prefrontal, Frontal, Central, Parietal) X Electrode Side Site (Left, Middle, Right) repeated measures ANOVA was conducted in order to assess differences in the AUC at the 950–1500 ms time points. (See Figs. 3 and 4 for grand averages of ERP waveforms).

A significant two-way interaction of Group X Trial Type was observed, $F(4, 102) = 6.61, p < .01, n_{p}^{2} = 0.21$. Additionally, a four-way interaction of Group X Paradigm type X Trial type X Electrode Side Site was found, $F(7.79, 206.55) = 2.00, p = .05, n_{p}^{2} = 0.07$. No other significant main effects or interactions involving the Group factor were found.

In order to probe the four-way interaction, Group (PTSD, non-PTSD, Control) X Trial type (Target, Distractor, Standard) X Electrode Side Site (Left, Middle, Right) repeated measures ANOVA's were conducted separately for each Paradigm Type (Anatomy, Blood, Morbid).

For the Anatomy Paradigm, a significant Group X Trial interaction was observed $F(3.01, 79.88) = 3.73, p < .05, n_{p}^{2} = 0.12$. To probe the interaction, repeated measure ANOVA's were conducted for each Trial Type. Results indicated a significant effect of Group on AUC values for only the Distractor Trial Type $F(2, 53) = 3.35, p < .05, n_{p}^{2} = 0.11$. Bonferroni post hoc tests revealed significantly larger AUC values for the PTSD ($M = 2412.78, SE = 231.54$) compared to the Control group ($M = 1566.51, SE = 231.54, p < .05$). No other main effects of interactions involving the Group Factor were observed. Fig. 6 illustrates the AUC values for the three experimental paradigms (Anatomy, Blood, Morbid) as function of Trial Type (Target, Distractor, Standard) for the three study groups (PTSD, non-PTSD, Control), averaged for all 12 electrodes.

For the Blood Paradigm, a significant effect of Group was observed $F(2, 53) = 3.37, p < .05, n_{p}^{2} = 0.11$. Bonferroni post hoc tests revealed significantly larger AUC values for the PTSD ($M = 2034.75, SE = 176.15$) as compared to the non-PTSD ($M = 1472.40, SE = 143.82, p < .05$). Additionally, a significant Trial Type and Group interaction was observed $F(3.47, 92.19) = 4.11, p < .01, n_{p}^{2} = 0.13$. In order to probe the interaction, repeated measures ANOVA's analyses, separate for each Trial Type (Target, Distractor, Standard) were conducted. For Target Trial Type, a significant effect of Group was observed $F(2, 53) = 3.60, p < .05, n_{p}^{2} = 0.12$. Bonferroni post hoc tests revealed significantly smaller AUC values for the non-PTSD group ($M = 1659.48, SE = 212.54$) as compared to the Control group ($M = 2546.53, SE = 260.30, p < .05$). For Distractor Trial Type, a significant effect of Group was observed $F(2, 53) = 5.00, p = .01, n_{p}^{2} = 0.16$. Bonferroni post hoc tests revealed significantly larger AUC values for the PTSD group ($M = 2575.98, SE = 236.73$) compared to the non-PTSD ($M = 1643.88, SE = 193.29, p < .01$) and Control ($M = 1775.33, SE = 236.73, p < .05$) groups. No significant main effects or interactions involving the Group factor were observed for Standard Trial Type (Fig. 6).

For the Morbid Paradigm, a significant Group X Trial Type X Electrode Side interaction was observed $F(4.75, 125.96) = 3.17, p < .05, n_{p}^{2} = 0.11$. Probing the interaction by separate repeated measures ANOVA's for each Trial Type have indicated a significant Group X Electrode Side interaction for Target Trial Type $F(2.55, 66.82) = 4.47, p < .01, n_{p}^{2} = 0.14$. Probing this interaction by repeated measures ANOVA's, separated for each side, indicated a significant effect of Group only for Right Side electrodes $F(2, 53) = 3.18, p = .05$, $n_{p}^{2} = 0.12$.

### Table 3

Means and standard errors of P300 amplitude (μV) and late negative component (LNC) area under the curve (μV*ms) values for the study groups across all paradigms and trial types.

<table>
<thead>
<tr>
<th></th>
<th>PTSD</th>
<th>Non-PTSD</th>
<th>Control</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>SE</td>
<td>Mean</td>
</tr>
<tr>
<td><strong>P300</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Anatomy Target</td>
<td>12.37</td>
<td>1.26</td>
<td>10.82</td>
</tr>
<tr>
<td>Distactor</td>
<td>6.13</td>
<td>1.00</td>
<td>7.05</td>
</tr>
<tr>
<td>Standard</td>
<td>5.28</td>
<td>0.85</td>
<td>5.34</td>
</tr>
<tr>
<td>Blood Target</td>
<td>11.83</td>
<td>1.58</td>
<td>9.25</td>
</tr>
<tr>
<td>Distactor</td>
<td>7.08</td>
<td>1.17</td>
<td>7.60</td>
</tr>
<tr>
<td>Standard</td>
<td>6.69</td>
<td>1.02</td>
<td>5.87</td>
</tr>
<tr>
<td>Morbid Target</td>
<td>9.68</td>
<td>1.48</td>
<td>9.28</td>
</tr>
<tr>
<td>Distactor</td>
<td>4.32</td>
<td>1.23</td>
<td>6.17</td>
</tr>
<tr>
<td>Standard</td>
<td>5.31</td>
<td>0.86</td>
<td>5.61</td>
</tr>
<tr>
<td><strong>LNC</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Anatomy Target</td>
<td>2195.93</td>
<td>268.46</td>
<td>1963.34</td>
</tr>
<tr>
<td>Distactor</td>
<td>2412.78</td>
<td>231.54</td>
<td>1944.48</td>
</tr>
<tr>
<td>Standard</td>
<td>1232.13</td>
<td>151.46</td>
<td>1240.05</td>
</tr>
<tr>
<td>Blood Target</td>
<td>2162.08</td>
<td>260.30</td>
<td>1659.48</td>
</tr>
<tr>
<td>Distactor</td>
<td>2575.98</td>
<td>236.73</td>
<td>1643.88</td>
</tr>
<tr>
<td>Standard</td>
<td>1386.21</td>
<td>159.53</td>
<td>1113.85</td>
</tr>
<tr>
<td>Morbid Target</td>
<td>2268.73</td>
<td>242.07</td>
<td>1798.68</td>
</tr>
<tr>
<td>Distactor</td>
<td>2027.85</td>
<td>239.17</td>
<td>1876.22</td>
</tr>
<tr>
<td>Standard</td>
<td>1298.07</td>
<td>238.30</td>
<td>1154.52</td>
</tr>
</tbody>
</table>

Note: All values are averaged for 12 electrodes.
In summary, our findings indicate that for the Anatomy and Blood paradigms, when subjects observed Distractors with Anatomy ("a pair of ribs") or Blood ("red blood") contents, the PTSD group responded with significantly larger AUC values compared to the non-PTSD group. For the Blood and Morbid paradigms, the response to neutral Target stimuli was significantly larger among Control subjects, compared to the non-PTSD group (although this effect was restricted to the Right Side electrodes and only for the Morbid paradigm). Table 3 displays group averages for the LNC analysis. Beyond Paradigm Type, our findings also showed a significantly smaller AUC among non-PTSD participants for Target Trials, compared to Controls, and larger AUC values among the PTSD group compared to Controls in response to Distractor Trials.

A significant main effect of Trial type was observed $F(2, 52) = 87.10, p < .05, \eta^2_p = 0.77$. Bonferroni post hoc tests revealed larger AUC values for Targets ($M = 2153.78, SE = 94.14$) as compared to AUC values elicited in response to Distractors ($M = 1939.00, SE = 92.80, p < .05$) as well as Standard stimuli ($M = 1275.70, SE = 78.69, p < .01$). The difference in AUC values for Distractors and Standard Trials was also significant ($p < .01$).

Finally, a significant main effect of Midline Electrode Site on AUC values was observed $F(1.34, 71.05) = 5.42, p < .05, \eta^2_p = 0.09$. Bonferroni post hoc tests revealed larger AUC values at the Prefrontal Electrode Site ($M = 1888.64, SE = 94.83$) as compared to AUC values at Frontal Site ($M = 1733.70, SE = 74.34, p < .01$). No other significant main effects or interactions involving the Group factor were observed.

4. Discussion

This is the first ERP study to examine the cerebral response to Rorschach’s Traumatic Content Index among a sample of trauma-exposed participants diagnosed with PTSD, trauma-exposed participants not meeting clinical criteria for PTSD, and Control participants unexposed to trauma. Our study found that trauma-exposed participants (PTSD and non-PTSD) exhibited different cerebral activation patterns in the presence of Anatomy, Blood and Morbid contents, than did Control participants. This finding indicates that, when faced with some TCI-related traumatic themes (Anatomy and Blood), trauma-exposed participant ERP’s will exhibit increased P3 amplitudes.

5. Allocation of attention

Larger P3 amplitudes have been postulated to indicate an allocation of greater attention (Polich & McIsaac, 1994). Thus, our findings indicate an allocation of more attention to some TCI-related stimuli among trauma-exposed participants. This concurs with the resource allocation model of PTSD (Ehlers & Clark, 2000) as well as with the neurocircuitry model of PTSD, denoting a deficit in PFC suppression of attention to trauma-related stimuli (Rauch et al., 1998, Rauch et al., 2006). Specifically, the results indicate that, in comparison to Control participants, trauma-exposed participants demonstrated an attentional bias toward Distractor phrases related to Anatomy and Blood, while their reaction to phrases related to torn, broken, or dysphoria-related objects (Morbid content) was characterized by reduced attention. Thus, the finding regarding Anatomy and Blood content supports our first hypothesis (i.e. participants with PTSD would exhibit larger P3 amplitudes in the context of TCI-related Distractors compared to non-traumatized Controls), while the Morbid content finding does not.

The elevated P3 response in both trauma-exposed groups (PTSD and non-PTSD) to Anatomy and Blood contents (but not Morbid) also supports our second hypothesis, which indicated that exposure to TCI-related content would be followed by increased P3 amplitudes in both the trauma-exposed groups (PTSD and non-PTSD), compared to the Control participants. These findings concur with the growing literature suggesting that attentional bias after an exposure to trauma...
are also found among participant that do not meet clinical criteria for PTSD (Kimble et al., 2010; Thomas, Goegan, Newman, & Arndt, 2013)

6. General hypervigilance pattern

In contrast to previous findings (Karl et al., 2006; Johnson et al., 2013) and to our third hypothesis (i.e. that participants with previous traumatic exposure would exhibit increased P3 amplitudes only in response to Target and Distractor stimuli), our findings showed that an increase in P3 amplitude to Anatomy and Blood content among trauma-exposed participants (PTSD and non-PTSD) was evident for all Trial types (Target, Distractor, Standard). This finding may be characterized as a general hypervigilant pattern, and may suggest impaired stimulus filtering. A recent magnetoencephalography (MEG) study of participants with PTSD found dorsolateral prefrontal-related hyperactivity to standard stimuli in the presence of threatening Distractors (Herz et al., 2016). While the Herz study’s results seem to provide some support for the current findings, further research is needed to examine a possible pattern of general hypervigilance among trauma-exposed individuals.

In summary, our ERP findings indicate that there is an attentional bias to the Anatomy and Blood TCI subjects among trauma-exposed participants, thus complementing the cognitive resource allocation model (Ehlers & Clark, 2000) as well as the neurocognitive neurocircuitry model (Rauch et al., 1998, Rauch et al., 2006) of PTSD. The findings support the explanation that the relatively high frequency of TCI responses in the Rorschach protocols of trauma-exposed individuals can be explained, at least in part, by activation of the individual’s traumatic imagery. This mechanism may be restricted to Anatomy and Blood contents, since the cerebral response to Morbid content among the trauma-exposed groups was attenuated.

7. Responsivity to different TCI categories

Beyond the above findings, this study also showed that trauma-exposed participants had higher cerebral responsivity to Anatomy and Blood Distractors (“a pair of ribs” or “a drop of blood”, respectively) along with attenuated responses to Morbid Distractors (“a baby’s body”). These differences can be explained neither by differences in level of perceived threat among Distractors of the three paradigms (Kimble et al., 2010) nor by PTSD-related sensitivity to negative emotional valance of the stimulus (Blomhoff et al., 1998; Saar-Askenazy et al., 2015). This position is informed by our study findings from two separate groups of age-matched undergraduate students who were asked to rate the threat and negativity levels of the TCI phrases. These groups rated the Anatomy phrases as significantly less threatening than Blood and Morbid phrases, while rating Blood and Anatomy as less negative than Morbid phrases

A higher cerebral responsivity to Anatomy and Blood Distractors might be related to trauma-exposed participants’ high responsiveness to stimuli that bear perceptual similarities to stimuli encountered during the trauma itself. These perceptual properties acquire the status of a warning signal through perceptual priming (Ehlers et al., 2002; Ehlers, Hackmann, & Michael, 2004). It has also been suggested that participants exposed to trauma focus on the central perceptual properties of an object rather than on its meaning due to narrow attention during the traumatic experience (Christianson, 1992; Ehlers & Clark, 2000; Ehlers et al., 2004; Suendermann, Hauschildt, & Ehlers, 2013; Van der Kolk & Fisler, 1995; Wing Lun, 2008). It might be that Anatomy and Blood Distractors used in the current study contained more perceptual information (like “smelly skull” or “red blood”) than Morbid Distractors that contained more affective and symbolic data (“depressed woman”, “broken toy”). These possible differences between TCI categories are also acknowledged by the Rorschach interpretive conceptualization in which Anatomy and Blood content is thought to reflect preoccupation with concrete bodily injury (Bohm, 1958; Meyer & Viglione, 2008) while Morbid content is thought to symbolize wounded self-image and relates to a general sense of inadequacy (Exner, 2001; Hartmann, Halvorsen, & Wang, 2013; Meyer & Viglione, 2008). Thus, it is possible that these differences may have triggered larger P3 in response to Anatomy and Blood than to Morbid Distractors. Notwithstanding, Distractors were not rated according to their level of perceptual/conceptual information within this study; furthermore, other explanations can be suggested for the current findings. For example, it is possible that the Anatomy and Blood Distractors were more conceptually related to the content of the participants’ primary traumatic event (Zhang et al., 2015), the vast majority of which were motor vehicle accidents or war/combat. Therefore, it is our recommendation that perceptual and conceptual levels of incoming stimuli on information processing among trauma-exposed individuals should be explored in future studies, in light of this novel finding.

8. Late negative component

This study’s findings extend beyond the P3 component. Although we had no preliminary hypothesis regarding possible effects of trauma exposure on later ERP components, evaluation of the grand averages of ERP waveforms and the resulting statistical analysis have revealed that the elevated P3 response of the PTSD group to Anatomy and Blood Distractors was followed by a significantly larger AUC values in the LNC. In the LNC results, participants with PTSD were characterized by increased responsivity to Distractors derived from the TCI, while the Controls showed increased responsivity to the Target (neutral) stimuli. Specifically, participants with PTSD were characterized by increased response to Distractors with Anatomy and Blood contents, as compared to Control participants. This pattern of response in a late component has not been previously documented.

Providing further context to this pattern is a study involving an emotional Stroop task that suggested its finding of an increased late (626–762 ms) negativity indicated an association between emotional arousal and late attentional processes that enroll higher order cognitive control mechanisms (Feroz, Liecht, Steinmann, Andreou, & Mulert, 2016). It is possible that in the present study, Anatomy and Blood Distractors elicited higher levels of arousal among participants in the PTSD group. Other ERP studies have related LNC to sensitivity to the number of items that are stored in working memory, and an index of filtering efficiency (i.e. the ability to exclude non-relevant items from working memory storage) (Qi, Ding, & Li, 2014; Vogel & Machizawa, 2004). Highly Trait Axious (HTA) individuals that showed large amplitudes of LNC were suggested to allocate excessive working memory storage to threatening Distractors, indicating inefficient filtering ability (Stout, Shackman, & Larson, 2013). This might also be the case in this study, indicating that PTSD participants who associated Anatomy and Blood contents with traumatic experience through perceptual priming required more working memory storage and elicited larger late negativity. This should be further explored in future studies.

Notwithstanding the above, this study’s results should be viewed within the context of the study design, and the previous hypothesis’ relevance to the current findings should be considered with caution. In the current study, an oddball paradigm was used, the LNC was reported at later time intervals than in previous studies, and was calculated as a measure of the AUC; in previous studies, other ERP paradigms were used and the late negativity was calculated as mean amplitude (Feroz et al., 2013; Stout et al., 2013).

Taken together, the findings for both P3 and LNC suggest a PTSD-related information processing pattern denoting increased responsivity to Anatomy and Blood Distractors in mid-latency time intervals followed by later increased cerebral response. These findings may point to impaired PFC top-down regulation influence on information processing. Another possibility is that these findings indicate a “vigilance-avoidance” pattern of information processing among individuals with PTSD: the increased P3 amplitude may signify an initial vigilance to cues that were perceptually primed and associated with danger,
followed by elevation of the late negativity indicating an effort to avoid or suppress the processing of emotional stimuli. Such a response pattern (Mathews, 1990; Mogg & Bradley, 1998) is supported by a number of behavioral studies indicating that, among participants with High Trait Anxiety or anxiety disorders, there is a significant initial heightened vigilance to threatening stimuli at the first 500 ms after stimulus presentation followed by avoidance of the aversive stimuli at very late latencies of approximately 1500 ms after stimulus onset (Amir, Foa, & Coles, 1998; Hermans, Vansteenhoven, & Eelen, 1999; Mogg, Bradley, Miles, & Dixon, 2004; Rohner, 2002). In summary, this study’s findings suggest that information processing alterations among participants with PTSD may extend beyond the P3 time interval, as indicated by the LNC alterations. Future studies should examine whether the increase in LNC is due to hyper-responsivity to trauma-related stimuli or reflects an attempt to avoid processing of such stimuli.

9. Study limitations

To the best of our knowledge, this is the first study examining the cerebral response to phrases from Rorschach’s Traumatic Contents Index among participants whose levels of PTSD symptoms have been validated by self-report questionnaires and semi-structured interviews. Notwithstanding, the current study has several limitations.

First, the generalizability of this study might be limited since all participants were young students, healthy, with minimal comorbidity and “moderate to severe” level of PTSD. Despite these factors, the fact that our results were obtained even among this selective subset of participants indicates the strength of the findings. Nevertheless, having a greater representation of the full range of ages and severity levels (including participants with extremely severe PTSD symptoms) would have increased the generalizability of our findings. Moreover, since no formal mental health evaluation was conducted, we cannot exclude the possible effects of undetected mental health problems on our findings. However, considering the fact that our participants were mainly young, high-functioning individuals, we theorize that the levels of the possible effects would be minor.

A second limitation may be the higher representation of females as well as an imbalanced gender ratio in some of the groups (Females made up: 12 of 16 PTSD, 14 of the 24 non-PTSD, and 14 of the 16 Control group members). Interestingly, a higher rate of females characterizes other related studies (Felmingham et al., 2002; Lobo et al., 2014). Regarding gender ratio: our analyses indicated no significant differences in male/female ratios between the study groups, and no significant effect of gender as a covariate in any of the analyses. Previous research also indicated negligible effects of gender on P3 characteristics (Rozenkraus & Polich, 2008). While we conclude that the imbalance in male/female ratio had no major effect on results, we suggest that, to some extent, this study findings may be more applicable to women and to trauma-exposed individuals whose posttraumatic symptom levels meets clinical criteria for PTSD.

Additionally, as noted previously, the absence of data on arousal levels of Distractors is a possible study limitation. While Distractors were evaluated for emotional valence and threat levels, and those analyses demonstrate the improbability of the heightened responsibility to Anatomy and Blood Distractors (compared to the Morbid Distractors) due to those factors, we did not rate Distractors according to their arousal level. Arousal may play an under-recognized role in the heightened responsivity observed among different categories of TCI Distractors used in this study. Even so, we believe that such possible arousal differences cannot fully explain variances in cerebral response within study groups. Arousal level effects have been mainly reported among non-disordered participants (Olofsson et al., 2008); thus, possible effects of arousal should be evident among Controls as well as traumatized participants. However, the current finding indicates significant differences between trauma-exposed and Control participants. Moreover, previous arousal research focused on evaluating responsivity to validated visual stimuli (Rozenkraus & Polich, 2008), while our stimuli were phrases adopted from the Rorschach, possessing no previous norms. Nonetheless, arousal, as well as emotional valence and level of perceived threat, should be further evaluated; we intend to evaluate TCI-related emotional arousal levels, and their possible effect on ERP’s, in future studies.

The null effect of Trial type (Target, Distractor, Standard) in this study may indicate a general, nonspecific hypervigilant information processing pattern among those with PTSD. However, another possibility is that the present study’s sample was underpowered to detect subtle effects of stimulus type. Moreover, only Blood, Anatomy and Morbid categories from the TCI were analyzed in our study. Therefore, future research should use a larger sample size and also examine the other two TCI categories (Sex and Aggressive Movement) to enable additional comparisons.

10. Conclusions

The present study findings support the previously suggested hypothesis that the perception of Rorschach inkblots as containing traumatic contents represents a breakthrough of intrusive traumatic imagery among those with PTSD (Viglione et al., 2012). Our findings also generate additional hypotheses that should be explored in future studies. One such hypothesis is that intrusive memories are elicited by perceptual properties of the inkblots primed by the traumatic experience. Another hypothesis is that phrases with Morbid content contains less perceptual information and that the higher frequency of Morbid responses observed in the Rorschach protocols of individuals with PTSD may stem from another mechanism.

Previous research has mainly focused on the conceptual or semantic associations between the traumatic experience and the processing of incoming stimuli in a current setting, those with PTSD have been thought to allocate attention to stimuli that were conceptually related to trauma through meaning via explicit memory representations. Cognitive-based intervention therapies for PTSD, such as Cognitive Processing Therapy (Reisick, Monson, & Chard, 2007) are, in fact, based on the premise that PTSD develops due to changes in the meaning of previous cognitions following traumatic event exposure, such as a change from a thought that “the world is a just place in which people get what they deserve” to “the world is an unpredictable, chaotic environment” (Ehlers & Clark, 2000; Janoff-Bulman, 1989). However, it is our contention that, in accordance with an accumulating body of research in recent years, our findings suggest the presence of another mechanism of action in PTSD: one in which attention is elevated when encountering stimuli that have been perceptually primed, organized in implicit memory representations, and associated with impending danger. If confirmed in future studies, this may have significant implications for PTSD treatment methodologies: this newly identified mechanism may be resilient to standard psychological intervention techniques that focus solely on altering conceptual, semantic-based cognition. Development of novel methods to reduce perceptually generated PTSD symptoms may be warranted.

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Table 1A
Trauma content index distractor phrase examples.

<table>
<thead>
<tr>
<th>Anatomy distractors</th>
<th>Blood distractors</th>
<th>Morbid distractors</th>
</tr>
</thead>
<tbody>
<tr>
<td>Smelly scull</td>
<td>A pond of blood</td>
<td>Split throat</td>
</tr>
<tr>
<td>Exposed intestine</td>
<td>Streaming blood</td>
<td>Wounded soldier</td>
</tr>
<tr>
<td>Brain tissue</td>
<td>Splashing blood</td>
<td>Leg amputee</td>
</tr>
<tr>
<td>Skeleton muscle</td>
<td>Congealed blood</td>
<td>Decaying body</td>
</tr>
<tr>
<td>A pair of ribs</td>
<td>A bloody fluid</td>
<td>Depressed women</td>
</tr>
<tr>
<td>Spinal cord</td>
<td>Flowing blood</td>
<td>Rotten apple</td>
</tr>
<tr>
<td>Liver lobe</td>
<td>Unbilical blood</td>
<td>A baby's body</td>
</tr>
<tr>
<td>Gall bladder</td>
<td>Spilled blood</td>
<td>Injured bear</td>
</tr>
<tr>
<td>Tail bone</td>
<td>Fresh blood</td>
<td>A torn curtain</td>
</tr>
<tr>
<td>A pair of lungs</td>
<td>Red blood</td>
<td>Broken toy</td>
</tr>
</tbody>
</table>

References


