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WASHINGTON UNIVERSITY

Department of Psychology

**Post-Traumatic Stress Disorder Severity, Dissociation, and Perceived Social Support Predict Performance on Event Processing and Memory Tasks**

by

Michelle Lisa Eisenberg

A thesis presented to the  
Graduate School of Arts and Sciences  
of Washington University in  
partial fulfillment of the  
requirements for the  
degree of Master of Arts

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## Abstract

The ability to segment ongoing activity into meaningful events is integral for event understanding and memory. Neuroimaging and behavioral studies suggest that Post-Traumatic Stress Disorder (PTSD) could impair some of the mechanisms of event segmentation, and that this may hurt subsequent memory. To test this hypothesis, 145 participants completed event segmentation and memory tasks; tests of working memory, episodic memory, general knowledge, executive function, and processing speed; and questionnaires assessing severity of PTSD symptoms, dissociation, and perceived social support. PTSD, dissociation, and perceived social support explained unique variance in event segmentation performance. Furthermore, social support explained unique variance in event memory. Difficulty segmenting events may affect PTSD patients' ability to interpret the activity occurring around them, and interventions aimed at improving event encoding may help compensate for memory disruptions in PTSD.

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## Introduction

Post-Traumatic Stress Disorder (PTSD) is a disabling disorder that 6.8% of American adults have experienced in their lifetime (Kessler et al., 2005). According to the *Diagnostic and Statistical Manual of Mental Disorders-IV-TR* (American Psychiatric Association, 2000), PTSD is an anxiety disorder caused by exposure to a traumatic event that produces intense fear, helplessness or horror in the victim. Symptoms of PTSD include reexperiencing (e.g., flashbacks), avoidance and numbing (e.g., avoidance of thoughts or places related to the trauma), and increased arousal (e.g., hypervigilance). These symptoms can severely interfere with daily functioning, often limiting a person's ability to work, raise a family, and participate in other activities of daily life.

While combat-related trauma is often considered the prevailing cause of PTSD, other traumatic events such as sexual trauma, car accidents, and natural disasters are also leading precursors of the disorder. Among combat veterans, lifetime PTSD prevalence is as high as 24-31% (Blake et al., 1990; Weiss et al., 1992), among rape victims, 47% were found to have chronic PTSD 3 months post-trauma (Rothbaum, Foa, Riggs, Murdock, & Walsh, 1992), and among vehicular accident survivors 23% met criteria for PTSD 4-6 months post-accident (Holeva, TARRIER, & Wells, 2001).

## **Memory**

In addition to the symptoms of PTSD discussed in the DSM-IV, people with PTSD often report other cognitive difficulties, such as deficits in declarative memory. Research in this area has been extensive, and while the results have not been in complete accord, there is strong evidence for memory and other cognitive deficits in populations of

PTSD patients. Vasterling, Brailey, Constans, & Sutker (1998) studied combat-veterans and found that participants with PTSD displayed greater difficulty than non-PTSD patients on a test of learning and categorized recall and on a test of short and long delayed recall. Furthermore, Vietnam veterans with PTSD displayed deficits on tests of sustained attention, working memory, and learning of verbal information (Vasterling et al., 2002).

Further research demonstrates that these memory deficits are unlikely to be due solely to other comorbid disorders. Gilberton, Gurvits, Lasko, Orr, and Pitman (2001) found that combat veterans with PTSD displayed deficits on memory tasks, even after controlling for the effects of comorbid depression, alcohol history, and intelligence. In addition, rape survivors without histories of alcohol or substance abuse performed more poorly on tasks requiring memory and attention than rape survivors without PTSD and non-rape survivors without PTSD. The difference between the groups remained significant after controlling for comorbid depression (Jenkins, Langlais, Delis, & Cohen, 1998; Jenkins, Langlais, Delis, & Cohen, 2000).

These cognitive deficits are also unlikely to be fully accounted for by premorbid intelligence differences between groups. Gil, Caley, Greenberg, Kugelmass, and Lerer (1990) compared pre-combat intelligence scores to post-combat scores, and found that the IQ scores of the PTSD group deteriorated significantly after the participants developed PTSD. Specifically, participants with PTSD demonstrated decreased scores on measures of memory, attention, and verbal fluency. These studies therefore suggest that the memory and cognitive deficits found in populations of people with PTSD are likely due to the disorder rather than to either pre-morbid or co-morbid conditions.



## **Dissociation**

People who experience traumatic events often report experiencing one or more dissociative symptoms, and peritraumatic dissociation at the time of a traumatic event has been found to predict later PTSD symptoms. Dissociation can take the form of out-of-body experiences, disruptions in perceived passage of time, and seeming unreality or distortions of the surrounding environment, among others (Marshall, Orlando, Jaycox, Foy, & Belzberg, 2002). Marmar et al. (1994) studied male Vietnam Theater veterans and found that peritraumatic dissociation, as measured by the Peritraumatic Dissociative Experiences Questionnaire (PDEQ), was highly correlated with PTSD scores on the Mississippi Scale for Combat-Related PTSD. This relationship held after controlling for level of war zone stress exposure and stress response. In addition, in a study of female Vietnam Theater veterans, Tichenor, Marmar, Weiss, Metzler, & Ronfeldt (1996) found a significant correlation between peritraumatic dissociation and scores on the intrusion and avoidance scales of the Impact of Events Scale. Surprisingly, the authors did not find a strong relationship between peritraumatic dissociation and PTSD as measured by the Mississippi Scale. The authors suggest that their disparate finding was likely due to restriction of range in the PTSD scores on the Mississippi Scale for the female Vietnam veterans, as the female veterans in this study had generally lower scores on this scale than the male veterans in the previous study.

A major limitation of these studies is that the authors assessed peritraumatic dissociation retrospectively. Shalev, Peri, Canetti, & Schreiber (1996) recruited 51 trauma survivors who were admitted into a hospital in Jerusalem. Peritraumatic dissociation measured between 2-6 days after hospital admission predicted PTSD status

as measured by the Structured Clinical Interview for DSM-III-R—Non Patient Version six-months post-trauma. Furthermore, in a multiple regression model, peritraumatic dissociation explained 29.4% of the variance in Mississippi scale scores. Birmes et al. (2003) provide further support for this relationship, finding that in a population of 35 victims of violent assault, participants who developed PTSD three months post-trauma had significantly higher peritraumatic dissociation scores within 24 hours of the assault than participants who did not develop PTSD. In addition, peritraumatic dissociation accounted for 25.8% of the variance in PTSD symptoms measured three months after the trauma. These studies provide strong support for the association between peritraumatic dissociation and later development of PTSD symptoms.

In addition to peritraumatic dissociation, researchers have repeatedly found that level of trait dissociation, often measured by the Dissociative Experiences Scale (DES), is related to severity of PTSD symptoms. Bremner et al. (1992), for example, studied 51 Vietnam combat veterans with and without PTSD and found that veterans with PTSD had scores on the DES that were two times higher than veterans without PTSD. The authors also found a significant correlation between trait dissociative symptoms and PTSD symptoms measured on the Mississippi Scale. These results held after controlling for extent of combat exposure. Furthermore, Marmar et al. (1994), found that trait dissociation in male Vietnam Theater veterans was highly correlated with PTSD symptom severity after controlling for war zone stress exposure and stress response. There is therefore robust evidence that both forms of dissociation are strongly related to PTSD.

## **Social Support**

Lack of perceived social support after experiencing a traumatic event is widely believed to influence the development and severity of PTSD symptoms. One of the first studies on the relationship between perceived social support and PTSD found that social network size and emotional support were significantly reduced in Vietnam veterans with PTSD compared to Vietnam veterans without PTSD and a sample of medical-service inpatients without combat exposure. These results were not due to pre-combat social support, as all three groups reported similar levels of social support prior to the war. The authors suggest that low levels of post-combat social support interacted with the stressors of combat to produce increasing levels of PTSD over time (Keane, Scott, Chavoya, Lamparski, & Fairbank, 1985).

Hyman, Gold, and Cott (2003), delved deeper into the relationship between social support and PTSD, determining the specific areas of social support that are most related to the development of PTSD. For a sample of 172 adult female survivors of childhood sexual abuse, the authors found that the perceived availability of someone willing to listen to one's problems (appraisal support) and one's ability to make positive comparisons of oneself to others (self-esteem support) were the best predictors of PTSD symptoms, explaining 10.6% of the variance in PTSD symptoms. Of these two, self-esteem support explained the most variance in PTSD symptoms, suggesting two possible explanations: (1) Self-esteem support counteracts the negative effects of self-blame common in this population, and (2) higher PTSD symptom severity drives away people who would otherwise provide self-esteem support.

Again, a limitation of these studies is that they are cross-sectional, rather than prospective and longitudinal. However, Solomon, Mikulincer, & Avitzur (1988) followed Lebanon war veterans from two years to three years post-war. First, cross-sectional results from each of the two time-points support the research discussed above in that lower levels of perceived social support were strongly related to the severity of PTSD symptoms. More importantly, the authors found that social support was significantly correlated with changes in the severity of PTSD symptoms over the one-year period of study. Unfortunately, though, this study is still unable to provide evidence for a directional causal relationship between social support and PTSD, as a decrease in PTSD symptom severity could lead to an increase in availability of social support just as an increase in social support could lead to a decrease in PTSD symptoms.

### **Cognitive Deficits in Subclinical PTSD**

Traumatic events are unfortunately exceedingly common for people in the United States and other countries. Breslau, Chilcoat, Kessler, and Davis (1999) found that of the general population of Detroit, Michigan, 61.4% of the participants had experienced at least one traumatic event and 39.2% had experienced two or more traumatic events. In Sweden, over 80% of the participants surveyed had experienced at least one traumatic event (Frans, Rimmö, Åberg, & Fredrikson, 2005) and in Australia, the percentage was greater than 57% (Creamer, McFarlane, & Burgess, 2005). While only a relatively small portion of these participants would likely have been diagnosed with clinical PTSD, a much larger percentage would likely have displayed at least one symptom of PTSD. In fact, many of the cognitive deficits discussed above hold, albeit to a lesser degree, for

people who meet some, but not all, of the criteria for PTSD. Lindem et al. (2003), for example, assessed PTSD symptoms using the Clinician Administered PTSD Scale and ranked symptoms on a continuous scale by calculating the frequency and intensity of the symptoms. PTSD symptom severity was correlated with difficulty learning and retrieving verbal information, deficits in short term memory, and variability in reaction time on a sustained attention task. It is likely that other cognitive tasks would show similar patterns across severity levels of PTSD.

### **Neural Correlates of PTSD: The Anterior Cingulate Cortex**

One of the most robust findings in the PTSD imaging literature is a decrease in activity in the rostral anterior cingulate cortex (ACC) of participants with PTSD compared to healthy controls. The rostral ACC (Brodmann's area 25, part of area 24, and part of area 32) interacts with many areas involved in emotion processing, including the amygdala and insula (Bush, Luu, & Posner, 2000). Unsurprisingly, then, the studies that have found less activation in this area tend to involve tasks that include emotional stimuli. Bremner et al. (2004), for example, conducted a PET study comparing the performance of women with childhood sexual abuse related PTSD to healthy controls on three types of Stroop tasks: a typical color-naming Stroop task, an emotional Stroop task in which participants were asked to name the color of emotional, rather than color, words, and a control task in which participants named the color of a string of Xs. During the color-naming Stroop task, both the PTSD and control participants displayed an increase in activity in the ACC compared to the control task. However, only the non-PTSD control group displayed an increase in blood flow to the ACC during the emotional Stroop task;

activity in the right ACC (Brodmann's area 32) for the PTSD group decreased significantly compared to the color-naming task.

Bremner et al. (1999a) found similar results when they asked female survivors of childhood sexual abuse with and without PTSD to recount narratives of their trauma and then listen to them during PET imaging. Compared to brain activity while listening to non-trauma related narratives, participants with PTSD displayed deactivation in one area of the ACC (right subcallosal gyrus, Brodmann's area 25) and failure of activation in another area (Brodmann's area 32) when listening to trauma-related narratives. Participants without PTSD did not display significant differences in ACC activation between the two types of narratives. Bremner et al. (1999b) found similar results in a population of combat veterans. When exposed to traumatic pictures and sounds, veterans with PTSD displayed decreased activation in the left ACC (Brodmann's area 32) and decreased activation in right and left subcallosal gyrus (Brodmann's area 25). Based on these results, the authors suggest that the brain's typical response to traumatic stimuli is to activate the rostral ACC, and that this type of activation fails to occur in people with PTSD.

On the other hand, recent studies have found that people with PTSD tend to display hyperactivation of dorsal ACC (part of Brodmann's areas 32 and 24), an area that is typically involved in tasks such as performance monitoring, response selection, and error detection (Shin et al. 2009). For example, Fronzo et al. (2010) compared the performance of women with PTSD related to intimate-partner violence to control participants on a face matching task, and found bilateral increases in activity in the dorsal ACC for the participants with PTSD when face targets were male compared to when face

targets were female. In addition, Bryant et al. (2005) found hyperactivity in the dorsal ACC of people with PTSD in an auditory oddball task that was unrelated to trauma and emotional processing. In a similar study, Felmingham et al. (2009) used the same auditory oddball task but also measured skin conductance response to target tones as a measure of autonomic arousal. The authors found that during target trials in which participants displayed a skin conductance response, participants with PTSD displayed greater dorsal ACC activation than controls. The authors suggest that the results of both of these studies may indicate that people with PTSD display increased attention, vigilance, and processing of salient stimuli, consistent with the hyperarousal symptoms of PTSD.

In addition, Britton, Phan, Taylor, Fig, & Liberzon (2005) found that compared to combat veterans without PTSD, combat veterans with PTSD displayed increased activity in the dorsal ACC while listening to a personalized script of their traumatic event. Furthermore, Shin et al. (2001) used an emotional Stroop task comparing combat-related to general negative words and found greater dorsal ACC activation in combat veterans with PTSD compared to combat veterans without PTSD.

Greater activation of the dorsal ACC may also be the tonic state of this area for people with PTSD. Shin et al. (2009) measured resting regional cerebral metabolic rate for glucose in veterans with PTSD, veterans without PTSD, and their identical, non-veteran co-twins and found higher glucose metabolic rates in the PTSD/non-veteran twin pairs compared to the no-PTSD/non-Veteran twin pairs in the dorsal ACC. The authors therefore suggest that hyperactivity of the dorsal ACC may be a risk factor for PTSD.

Together, these studies provide strong evidence that people with PTSD display non-normative functioning in two major areas of the ACC: decreased activity in rostral ACC and hyperactivation of dorsal ACC. These findings suggest that these brain areas may influence the onset and symptoms of PTSD, and indicate that a greater understanding of how this non-normative functioning is related to PTSD would be useful in expanding current knowledge about the disorder.

Research on the ACC in other areas of psychology and neuroscience provides a plausible link between the non-normative ACC function seen in PTSD and some of the symptoms of PTSD. The ACC, particularly the dorsal ACC, is often implicated in tasks involving error detection and conflict monitoring (e.g., Holyroyd et al., 2004; van Veen, Cohen, Botvinick, Stenger, & Carter, 2001). However, a more recent view of the ACC is that it responds in proportion to the likelihood of an error on a particular task (Brown & Braver, 2005). To test this hypothesis, Brown & Braver used a computational model of the stop-signal paradigm, and found that the model predicted an increase in activity in the ACC on trials with a greater likelihood of prediction error. This held even for correct trials in which no error was actually made. The authors then compared the model to human fMRI data, and found that dorsal ACC activation supported the model predictions. The authors therefore suggest that ACC activation increases in proportion to the likelihood of making an error and receiving negative reinforcement.

This model has not yet been studied in people with PTSD; however, based on previously discussed research, it is possible that people with PTSD would display hyperactivation of the dorsal ACC at times of greater prediction uncertainty—times when there is a greater likelihood of making an incorrect prediction. People with PTSD may



manifest this perception of greater prediction error with a heightened arousal and startle response to stimuli that would not elicit such a response in people without PTSD. It is possible that the hyperarousal symptoms of PTSD reflect this response to increased error perception.

### **Event Segmentation, Error Prediction, and Anterior Cingulate Cortex**

If prediction error monitoring is disrupted in PTSD, this could affect patient's comprehension of everyday events. Prediction is an integral piece of the mechanism that allows people to segment ongoing activity into meaningful units, an essential ability for event understanding and memory. People constantly perform this type of segmentation throughout their daily lives. For example, when asked about what one did to get ready in the morning, one might mention waking up, getting out of bed, putting on clothes, eating breakfast, etc. It is clear that even in this simple description it is natural to segment activity into meaningful units. Each of the units in this example can also be broken up into smaller units, and depending on the wording of instructions, it is possible for people to successfully segment activity at a desired grain of coarseness.

In the lab, event segmentation is often studied by asking participants to watch a short movie of an everyday event, such as a woman making breakfast. Participants are told to push a button every time they believe a meaningful unit of activity has occurred. Research has demonstrated that not only are participants reliable across time if they segment the same movie on multiple occasions, but that the locations of these event boundaries within a given movie also tend to be stable across participants and studies (Zacks, Speer, Vettel, & Jacoby, 2006). Furthermore, there is strong evidence that people

segment ongoing activity not only during laboratory tasks, but also during everyday life. In a study by Zacks et al. (2001), participants watched movies of everyday events while in an fMRI scanner. First, participants were told to simply watch the movies and learn as much about them as possible. Later, participants segmented the movie into meaningful events. The authors found that transient changes in activation occurred in the same brain areas during both passive viewing and active segmentation. Because the passive viewing task occurred before the authors introduced any mention of event segmentation, this study suggests that people segment ongoing activity spontaneously and effortlessly during every day life.

Event memory is strongly tied to the process of event segmentation. When people perceive an event boundary, memory for the previous event is shifted out of short-term memory and memory for the new event replaces it (Speer & Zacks, 2005; Swallow, Zacks, & Abrams, 2009). In addition, people tend to report stronger memories for what occurred at event boundaries than for activity occurring during an event (Newtonson & Engquist, 1976; Schwan, Garsoffky, & Hesse, 2000). Furthermore, people who place event boundaries at normative locations tend to have better memories for what occurred during a movie. Although older adults tend to be more variable in their placement of event boundaries and typically have worse memory for what they have just watched than younger adults, older adults who segment like younger adults tend to remember events at the level of younger adults. Abnormal segmentation is therefore linked to decreased memory for segmented action sequences (Zacks et al., 2006).

Zacks, Speer, Swallow, Braver, and Reynolds (2007) proposed Event Segmentation Theory (EST) to model the sequence of processes occurring during event

segmentation (Figure 1), and prediction plays a central role in this model. As people experience the world, sensory information enters the primary sensory areas of the brain and is processed into multi-modal representations of objects, motion, and characteristics of people. During this processing stage, the brain makes predictions about future inputs, and these predictions are maintained in the ACC. As an example, if one were watching the motion of a ball, one would likely predict that after the ball reaches the apex of its ascent, it would immediately begin descending toward the ground. In order to make these types of predictions, the brain must also rely on a multi-modal representation of “what is happening now” (Zacks et al., 2007, p. 274), called an event model. Importantly, event models are unaffected by transient changes in sensory input, and are therefore not disrupted when sensory input is interrupted. For example, when watching a juggler toss balls into the air, a passing person occluding the balls from view would not disrupt the event model holding one’s goal of watching the performance. However, event models are subject to input from event schemata, which hold semantic memory representations of typical sequences of events. For example, the event schema for tossing a ball into the air might be throwing the ball into the air, watching it reach its apex, paying attention to where it will coming down, reaching out one’s hand to catch it, and then repeating this sequence of actions. Event schemata can also hold information about the goals of other people and the statistical likelihood that action sequences within an event will follow a specific pattern.

In order for the brain to make valid predictions about future inputs, the event model and event schema must accurately represent the current state of the world. Error detection mechanisms in the dopaminergic areas of the brain compare the predictions

held in the ACC with the sensory information entering the brain. Normally, event models are good representations of what is happening in the world; however, when activity in the world becomes less predictable and event models are no longer as accurate, prediction errors accrue, triggering a gating mechanism that allows incoming sensory information to update the event model. As this occurs, prediction errors decrease, closing the gating mechanism and once again preventing transitory sensory information from influencing the event model. The periods of time between updates are perceived as events, and the transient periods of updating are perceived as event boundaries.

As discussed above, prediction and prediction error play an integral role in event processing, with the ACC hypothesized to be the brain area where these predictions are maintained. These mechanisms provide the critical link between event segmentation and PTSD. However, to our knowledge, there has been no research merging these two areas of study. Clearly, though, a greater understanding of how people with PTSD make predictions and process information could help clinicians and researchers gain further insight into the symptoms, such as hyperarousal, seen in people with PTSD. Therefore, the present study aimed to determine whether severity of PTSD symptoms, dissociation, and level of perceived social support predict performance on event segmentation and event memory tasks. Because previous research has demonstrated that people with PTSD often have other cognitive deficits, we sought to determine whether these relationships hold when controlling for level of education and general cognitive function.

## Method

*Participants.* Participants were recruited from a pool maintained by the Washington University Volunteer for Health program and from the St. Louis, MO and surrounding area community by advertising. All potential participants were screened over the phone and excluded from the study if they reported: (a) having a mental illness such as schizophrenia, depression, anxiety, bi-polar disorder, ADHD, autism, phobias, or sleep disorders, (b) having a neurological disorder, (c) currently taking anti-depressants other than SSRIs, or (d) taking benzodiazepine, lithium, or sleeping pills other than Lunesta or Ambien. Two hundred thirty-three adults (mean age = 49.2 years, range = 20-79) met the screening criteria and were recruited for the study. Eighty-eight of these participants were dropped from analysis because of failure to complete and/or return PTSD questionnaires (63; see Sargent et al., unpublished manuscript, for additional analyses that include these 63 participants), inability to attend both study sessions within one week (8 participants), likely dementia (9 participants), missing segmentation data (5 participants), previous familiarity with the task (2 participants), and cheating on tasks (1 participant).

One hundred forty-five participants (mean age = 50.17 years, range 20-79, 21-29 participants in each decade) were included in the analysis. The mean age of the excluded participants did not differ from that of the included participants ( $t(231) = -1.089, p > .05$ ). Thirteen of the excluded participants did not provide their level of education; however, for the data available, mean levels of education did differ between the included (mean = 14.96) and excluded participants (mean difference = -0.77,  $t(218) = -2.115, p < .05$ ). Finally, for the 63 excluded participants who completed the event segmentation task, the

included (mean = 0.6) and excluded participants did not differ in their performance on the event segmentation task ( $t(206) = -1.336, p > .05$ ).

Participants received \$10 per hour of participation in the study, averaging to \$50 for completing the lab-based portion of the study and an additional \$10 for agreeing to complete the PTSD and associated questionnaires. The procedure was explained fully to the participants, after which they provided written informed consent to participate in the study. This study received approval from the Washington University Human Resources Protection Office.

*Materials, Tasks, and Procedure.* The study consisted of two sessions, each of which was approximately two-and-a-half hours long. Participants first viewed three movies of actors engaging in everyday activities: making breakfast (female actor, 329s duration), setting up for a party (male actor, 376s duration), and planting window boxes of plants (male actor, 354s duration). A fourth movie of a man building a boat from duplex blocks (155s duration) was used as practice. The movies were shot from a fixed head-height perspective without cuts or camera movement. Each movie began several seconds before the actor appeared on screen and ended several seconds after the actor left the scene. The movies were presented using PsyScope (Cohen, MacWhinney, Flatt, & Provost, 1993) on Macintosh computers. While viewing these movies, participants engaged in an event segmentation task, for which they were told to push a button on the keyboard whenever they believed “one natural and meaningful unit of activity has ended and another has begun.” During this session, they were instructed to identify the largest possible meaningful units of activity. They were informed that there were no correct or

incorrect answers for this task. Participants practiced this task while watching the duplex blocks movie, and an experimenter answered any questions they raised.

Following each movie, participants completed three memory tasks. Participants first completed a free recall task, in which they had seven minutes to write or type as much as they could remember from the movie in the order in which the activity occurred. Participants then completed a 20-trial recognition memory task on the computer. During each trial, two still images, one from the movie they just watched and one from a similar foil movie appeared next to each other on the screen. Participants indicated which still picture was from the movie they just watched by pressing a button on the keyboard. Finally, participants completed an order memory task. Twelve stills from the movie they just watched were placed on the table in a predetermined random order, and participants were instructed to arrange these images in temporal order as quickly as possible.

Participants then completed three working memory span tasks: reading span (Kane et al., 2007), operation span (Unsworth, Heitz, Schrock, & Engle, 2005), and symmetry span (Kane et al., 2007). For the reading span task, participants read and made judgments about sentences while remembering a sequence of letters presented one at a time after each sentence judgment. The operation span task required participants to solve math problems while remembering a sequence of letters presented one at a time after each math problem. For the symmetry task, participants indicated whether a grid pattern was symmetrical while remembering the sequence of locations of a red square on a 4x4 grid.

During the remainder of the first session, participants completed three tasks on the computer: a speed of processing task, a reading with distractions task (Connelly, Hasher,

& Zacks 1991), and a synonym and antonym vocabulary test (Salthouse, 1993). The speed of processing task required participants to pick which shape on a computer screen was most similar to a shape displayed at the top of the screen (Chen, Hale, & Myerson, 2007). For the reading with distraction task, participants read aloud stories that were interspersed with either a series of Xs (control condition) or distracting words (experimental condition). Reading times on the two conditions were compared to determine how susceptible participants were to distraction. The synonym and antonym task simply required participants to provide synonyms or antonyms for lists of words.

Between sessions one and two, participants filled out a packet of questionnaires containing the International Personality Item Pool (IPIP; Goldberg et al., 2006), the Morningness-Eveningness Questionnaire (Horne & Ostberg, 1976), a demographics questionnaire, and the AD8, a brief self-assessment questionnaire that can distinguish people with very mild dementia from people without dementia (Galvin, Roe, Coats, & Morris, 2007).

During the second session, participants first repeated the event segmentation task with the same movies, but this time were instructed to segment the movie into the smallest possible meaningful units of activity. Participants then completed the first part of a selective reminding task (Buschke, 1984). For this task, the experimenter showed participants pictures of sixteen items to remember. Participants then recalled as many of the items as possible, after which the experimenter gave category cues to help participants remember the remaining items. Participants completed three trials of this task. Participants then completed letter and pattern comparison tasks (Salthouse & Babcock, 1991). For these tasks, participants were asked to determine whether two



strings of letters were the same or different and whether two patterns of lines were the same or different. Next, participants completed the Information and Picture Arrangement subtests of the Wechsler Adult Intelligence Scale (WAIS) III (Wechsler, 1997). Then, participants completed the Ruff Figural Fluency test (Ruff, Light, & Evans, 1987), which required them to create as many unique patterns as possible by drawing lines connecting dots. The experimenter then returned to the selective reminding task (after an approximately 30 minute delay), and instructed participants to recall as many of the original items as possible. Category clues were given for any items that were not immediately recalled. Next, participants completed the immediate recall portion of the Verbal Paired Associates subtest of the WAIS III followed by two trail-making tasks (Armitage, 1946). For the first trail-making task, participants were told to draw lines connecting twenty-five numbers in the correct numerical order, and the second task required participants to draw lines alternating between letters and numbers in the correct alphabetical and numerical sequence. Participants then completed a script elicitation task (Rosen, Caplan, Sheesley, Rodriguez, & Grafman, 2003), for which participants wrote down the sequence of steps associated with carrying out three common activities. Participants then completed a spatial memory task during which they watched a short movie of objects located around a park, and were later instructed to place icons of the named objects in the correct locations around the park. The experimenter then conducted the second part of the Verbal Paired Associates task (an approximately 30 minute delay). Afterwards, participants completed the Short Blessed Test (Morris et al., 1989), a screening test for dementia. Finally, participants completed two trials of the Victoria Longitudinal Study free recall task (Dixon & de Frias, 2004), for which they memorized

a list of thirty English nouns and then wrote down as many as they could remember.

These methods are also discussed in detail in Sargent et al. (unpublished manuscript).

After finishing these tasks of cognitive function, participants were asked if they were willing to participate in an additional part of the study. If they agreed, they signed an additional consent form approved by the Washington University Human Resources Protection Office. The experimenter then gave them a packet with PTSD-related questionnaires. Included in this packet were the Traumatic Life Events Questionnaire (TLEQ; Kubany et al., 2000), the PTSD Screening and Diagnostic Scale (PSDS; Kubany, Leisen, Kaplan, & Kelly, 2000), the Peritraumatic Dissociative Experiences Questionnaire–Self Report Version (PDEQ; Marmar, Weiss, & Metzler, 1998), the Dissociative Experiences Scale (DES; Bernstein & Putnam, 1986), and the Multidimensional Scale of Perceived Social Support (MSPSS; Zimet, Dahlem, Zimet, & Farley, 1988). Also included in the packet was a list of treatment providers for PTSD and other disorders that are located in the St. Louis area, for use in the event that a participant experienced distress while completing the packet.

The TLEQ asked participants about twenty-two types of possible traumatic events. Participants reported whether they had experienced each type of event, the number of times they had experienced the event, whether they experienced fear, helplessness, or horror during the event, and whether they were seriously injured due to the event. They then indicated which of these events currently caused them the most distress. Participants were instructed to complete the PSDS using the event they indicated on the TLEQ. The PSDS is a thirty-eight item questionnaire designed to assess severity of PTSD symptoms. It has high internal consistency ( $\alpha = 0.93$ ), test-retest reliability

( $r = .95$ ), and convergent validity (Kubany, Leisen, Kaplan, & Kelly, 2000). PTSD symptom severity scores were calculated using scores on questions four through twenty-three, for which participants rated on a five point scale the degree to which they had experienced each of seventeen symptoms of PTSD during the previous thirty days. PTSD symptom severity ratings can range from zero to eighty, and a score of seventeen or above indicates clinical levels of PTSD.

The PDEQ consists of ten questions asking about dissociative experiences that occurred at the time of the traumatic event participants identified on the TLEQ. The measure has reasonable internal consistency ( $\alpha = 0.79$ ; Birmes et al., 2003). Scores on the items were summed to generate a total score for this measure. The DES asks about twenty-eight dissociative symptoms that participants may experience during everyday life. The scale has high internal consistency ( $\alpha = 0.93$ ) and test-retest reliability ( $r = 0.78-0.93$ ), and good convergent and divergent validity (van Ijzendoorn & Schuengel, 1996). Scores on this measure were summed to generate a total score for the DES.

The MSPSS is a twelve-item questionnaire that assesses levels of perceived social support. The scale has high internal consistency ( $\alpha = 0.88$ ) and test-retest reliability ( $r = 0.85$ ). It also has strong factorial validity and good construct validity (Zimet et al., 1998).

*Computing Segmentation Agreement.* The time courses for each of the movies were divided into one-second bins, and the time points at which each participant segmented the movies were placed in the appropriate bins. This generated normative data indicating the locations at which participants were most likely to segment the movies. Each participant's own segmentation was compared to the normative data to obtain a

segmentation agreement score. This score was then scaled to take into account the number of times each participant segmented the movies. The resulting scaled segmentation agreement scores were used for all analyses that included this variable.

*Scoring Event Memory Free Recall.* Using methods similar to those described in Schwartz (1991), three experimenters independently viewed each movie and listed in fine grain every meaningful action performed by the actor in the movie. Participants received one point for every phrase in their free recall data that matched one of the units on the scoring template. The final event memory score for each participant was calculated by summing the points obtained for each movie and then averaging across movies. The order in which participants wrote these units was also recorded on the scoring template. Two independent experimenters coded free recall data from all three movies for 3 participants ( $\kappa = 0.84$ ). Interrater reliability was therefore determined to be sufficient, and one investigator scored all of the free recall data from the participants in the current study.

## Results

*PTSD Symptom Severity, Dissociation, and Perceived Social Support.* PTSD symptom severity scores obtained from the PSDS ranged from 0 to 58. Forty-one participants had PTSD symptom severity scores equal to or greater than 17, the cutoff for clinical PTSD. Scores on the PDEQ ranged from 0 to 48, and scores on the DES ranged from 0 to 176<sup>1</sup>. Scores on the MSPSS ranged from 0 to 84. See Table 1 for the descriptive statistics for these measures and Figure 2 for the histograms of these distributions.

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<sup>1</sup> There was one far outlier in the distribution of DES scores. However, after log transforming the data, this participant was no longer an outlier on this measure. In addition, running all of the analyses with this outlier excluded did not change the results reported here.

Because the distributions of scores on these questionnaires were highly non-normal, analyses were designed to account for this non-normality, as discussed below.

*Preliminary Analyses.* To reduce error and loss of degrees of freedom in later analyses, we combined scores on the cognitive tasks described above into five composite variables: working memory, verbal episodic memory, general knowledge, executive function, and processing speed. See Table 2 for the tasks included in each composite variable as well as means and standard deviations for each variable. To create the composite variables, we z-scored the scores for each of the tasks and then averaged the resulting scores. However, because the measures of executive function did not form a latent variable in a confirmatory factor analysis (see Sargent et al., unpublished manuscript), this composite was dropped from further analyses.

Reliability for two measures of event memory—recognition memory and order memory—was low (Cronbach’s alpha of .47 and .5, respectively across the three movies); these tasks were therefore not included in the subsequent analyses. Event memory was therefore measured solely by performance on the free recall task (Cronbach’s alpha of .79 across the three movies).

Five participants in this study did not provide data for their level of education. Missing values were therefore imputed using data from the non-PTSD-related measures of 208 participants (the participants in the present study in addition to the 63 participants who were excluded because they failed to return the PTSD-related measures) using the expectation maximization (EM) procedure in SPSS 19.0.

To determine whether to include age and education level in the analysis, we correlated these variables with PTSD symptom severity and segmentation agreement. We

found significant correlations between age and PTSD ( $r = -0.235, p < .05$ ) and education level and PTSD ( $r = -0.225, p < .05$ ). In addition, education level was significantly correlated with segmentation agreement ( $r = 0.164, p < .05$ ); however, age and segmentation agreement were not significantly correlated ( $r = -0.025, p > .05$ ). Both of these variables were therefore included in the subsequent analyses.

To determine whether we could conduct a standard hierarchical multiple regression analysis, we checked the distribution of the age, education, PTSD symptom severity, dissociation, perceived social support and composite variables. All except for the PTSD symptom severity, dissociation, and perceived social support variables were normally distributed. Despite the non-normality of the predictors, the residual distributions were normal and homoschedastic, and parametric statistics were therefore used in the following analyses<sup>2</sup>.

*Predicting Segmentation Agreement.* Age was entered first into the equation, followed by education. The four composite variables were then entered into the equation. Together, these variables accounted for 17.6% of the variance in segmentation agreement ( $p < .05$ ). When PTSD symptom severity was added into the model after these variables,

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<sup>2</sup> To test the strength of our conclusions, we also conducted permutation analyses to obtain empirical distributions for the expectations of the regression parameters under the null hypothesis. For each variable of interest, we shuffled the scores for each participant and randomly assigned each participant one of these shuffled scores. This created a random distribution of scores that maintained the same skewed distribution as the original variable. The shuffled variables were then used in multiple regression analyses. Of interest in these analyses was whether the change in R-square obtained from adding the variable of interest to the regression equation was significant. We ran 10,000 iterations of each test to create a distribution of R-square change values that would be expected assuming the dependent measure was unrelated to the independent measures. R-square change values obtained from the original variable were determined to be significant if they fell in the 5% tail of the permuted R-square change distribution. The results of the analyses remained the same using this non-parametric test.

it accounted for an additional 4% of the variance in segmentation agreement ( $p < .05$ )<sup>3</sup>. When the two dissociation scores were entered into the model after age, education, and the composite variables, dissociation explained an additional 4.4% of the variance in segmentation agreement ( $p < .05$ ). However, most of the explained variance was due to scores on the DES, and when the PDEQ was removed from the model, scores on the DES explained 4.3% of the variance in segmentation agreement ( $p < .05$ ). Because PTSD symptom severity and scores on the DES and PDEQ were highly correlated, neither variable explained additional significant variance when entered after the other, though together they accounted for a total of 6.2% of the variance in segmentation agreement. We entered perceived social support last into the model, after age, education, the composite variables, PTSD symptom severity, and the dissociation scores, and found that social support accounted for an additional 3.8% of the variance in segmentation agreement ( $p < .05$ ). The model therefore explained a total of 27.6% of the variance in segmentation agreement<sup>4</sup>. See Figures 3-5 for scatter plots of the correlations between PTSD, dissociation, and perceived social support with segmentation agreement<sup>5</sup>.

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<sup>3</sup> To test the strength of this conclusion, we progressively deleted data points from the positive tail of the PTSD distribution to determine whether outliers on this scale were artificially inflating the correlation between PTSD and segmentation agreement. We found that 7.5% of these data points could be deleted (11 subjects) before the correlation became non-significant.

<sup>4</sup> In these models, perceived social support was entered last because it was the most exploratory of the variables tested in these analyses. However, when perceived social support was entered into the model before PTSD symptom severity, the coefficients for both perceived social support and PTSD symptom severity remained significant. The same pattern held when MSPSS scores were entered before DES scores.

<sup>5</sup> There was one outlier in the distribution for segmentation agreement. The analyses reported above include this outlier in the data. However, when this outlier was removed from the data, all of the results described above remained significant.

*Predicting Event Memory.* Again, age was entered first into the equation, followed by education and the five composite variables. Together, these variables accounted for 40.5% of the variance in event memory. Neither PTSD nor dissociation explained additional unique variance in event memory, though together they explained 1% of the variance in event memory. On the other hand, perceived social support did account for an additional 2.6% of the variance in event memory ( $p < .05$ ). In total, the model explained 44.1% of the variance in event memory. See Figure 6 for a scatter plot of the correlation between perceived social support and event memory.

*PTSD Symptom Severity Correlated with Cognitive Functioning, Perceived Social Support, and Dissociation.* We conducted bivariate correlations between PTSD and each of the four composite variables. Only the general knowledge composite variable was significantly correlated with PTSD symptom severity ( $r = -0.210$ ,  $p < .05$ ). See Table 3 for the correlation coefficients and significance tests between PTSD symptom severity and the composite variables. The relationship between PTSD and perceived level of social support was significant ( $r = -0.22$ ,  $p < .05$ ). In addition, the interaction between perceived social support and PTSD symptom severity did not explain any additional variance in segmentation agreement when entered into a regression equation after age, the composite variables, PTSD centered around its mean, and perceived level of social support centered around its mean. Finally, PTSD symptom severity was significantly correlated with scores on the DES ( $r = 0.42$ ,  $p < .05$ ) and scores on the PDEQ ( $r=0.53$ ,  $p < .05$ ).



## Discussion

Our results revealed that even after controlling for age, level of education, and general cognitive function, PTSD symptom severity, trait dissociation, and level of perceived social support significantly predicted event segmentation performance. Level of perceived social support also predicted event memory performance.

*Severity of PTSD Symptoms, Segmentation Agreement, and Event Memory.* Our finding that severity of PTSD predicts event segmentation agreement supports our hypothesis, and is in accord with the literature on PTSD and on event segmentation. As many imaging studies of PTSD patients demonstrate, the rostral ACC displays lower levels of activity in participants with PTSD versus controls during a variety of tasks related to traumatic events, whereas the dorsal ACC displays increased levels of activity in people with PTSD during tasks that are more cognitive in nature. Although, to our knowledge, there has not been any research on dorsal ACC activation in people with PTSD during tasks involving prediction, research on the ACC in other domains has found that dorsal ACC is activated at times of greater prediction error. This finding links the PTSD and ACC literature to that of event segmentation. Prediction and prediction error play an integral role in event segmentation: indicating where people should place an event boundary. Our finding that PTSD symptom severity predicts event segmentation performance suggests that people with PTSD may employ non-normative prediction processes, and therefore segment and process information differently, than people without PTSD. Future research should determine whether people with PTSD display differences on tasks explicitly testing prediction ability compared to people without PTSD. In addition, future studies should employ functional imaging to determine whether

the ACC shows decreased activation in participants with PTSD during event segmentation and explicit prediction tasks.

These results also have implications for understanding the mechanisms involved in PTSD. Although more research in this area is necessary, it is possible that some people who experience a traumatic event experience neural changes, specifically decreased activation in the rostral ACC and hyperactivation of the dorsal ACC, that may alter the way they perceive both their initial traumatic event and later events. Hyperactivation of the dorsal ACC may contribute to an increase in errors of prediction, possibly leading people with PTSD to be chronically hypervigilant in their search for danger. At the same time, lower levels of activation in the rostral ACC may lead people with PTSD to display less attention to environmental indicators of safety. These information processing errors may be reflected in and possibly augmented by the non-normative segmentation displayed by people with a higher severity of PTSD symptoms.

Though this mechanism postulates that experiencing a traumatic event leads to neural changes in the ACC, another plausible mechanism is that people who already display lower activation of the rostral ACC and hyperactivation of the dorsal ACC before experiencing a traumatic event are at a higher risk for developing PTSD. If correctly processing and understanding events requires normative ACC activation and event segmentation performance, people who have deficits in these areas may be predisposed to develop PTSD, a syndrome that by definition involves a failure to interpret events in an adaptive manner.

Surprisingly, we found that PTSD symptom severity did not predict event memory and that the five composite variables were not significantly related to PTSD

symptom severity, findings at odds with much of the literature on cognitive functioning and PTSD. It is possible, however, that we would have found correlations between PTSD symptom severity and memory had we used the same measures used in previous studies. Yehuda et al. (1995) found that immediate memory for a word list was not impaired in combat veterans with PTSD; however, delayed recall after interference from a second word list was impaired in the participants with PTSD. However, because the composite variables included a variety of semantic memory and working memory tasks, though not necessarily the exact tasks described in previous studies, this explanation may be less compelling.

A more likely explanation is that these discrepant findings may be due to the fact that the distribution of the PTSD symptom severity scores in this study was highly negatively skewed, with relatively few people above the clinical cutoff for PTSD. Although the statistics used to analyze this data were not affected by the skew of the data, it is possible that there were not enough people with clinical PTSD in this study to replicate the results of previous studies of clinical populations. Perhaps people with subclinical levels of PTSD display difficulty with event segmentation but do not have impairments at a level that significantly affects their memory. Future research on event segmentation and memory in a population with a greater proportion of people with clinical levels of PTSD would help to elucidate these surprising findings.

Another possible reason why we failed to find a relationship between PTSD and event memory may be that the movies in this study were unlikely to activate participants' traumatic memories. Previous studies have found the robust result that rostral ACC is less active in people with PTSD, and it is therefore likely that people with PTSD would

display even more difficulty on event segmentation tasks if their traumatic memories were activated during the task. This could be implemented either by activating participants' traumatic memory before they watch and segment the movies or by including movies with scenes related to their traumatic event. It is possible that increased difficulty with event segmentation would lead to a stronger relationship between PTSD symptom severity and event memory. Future studies are necessary to test this claim.

Despite the fact that we did not find a significant relationship between PTSD and event memory in this study, understanding how people with PTSD segment ongoing activity may still be relevant for understanding PTSD patients' memory complaints. The non-normative event segmentation we found in people with a higher severity of PTSD symptoms likely affects them not only during the lab-based segmentation tasks, but also during everyday life. Because previous studies have found a strong relationship between event segmentation and memory, it is possible that people with severe PTSD would display memory difficulties in their daily lives because of their difficulty processing ongoing activity. Future studies that include a greater number of people with more severe PTSD would be helpful to further elucidate this relationship.

These results may also inform treatment for PTSD. If the mechanism involved in segmentation were disrupted in people with PTSD, perhaps training in event segmentation could help reset the mechanism and restore normative event processing. For example, it may be possible to have people view movies that have been previously segmented by a non-patient sample while providing explanations for each boundary placement. People could later practice segmenting movies while receiving feedback to help them learn to segment more normatively. Future research is necessary to determine

whether this form of training is effective and whether learning to segment specific movies transfers to the segmentation of other movies and stimuli.

*Dissociation, Segmentation Agreement, and Event Memory.* Our finding that scores on both of the dissociation measures were correlated with PTSD was not surprising, given the existing literature on PTSD and dissociation. However, our finding that scores on the DES predict segmentation agreement was novel, and is not, to our knowledge, present elsewhere in the literature. The DES measures trait dissociation, and includes many items about experiences that involve lack of attention to the present situation. Although more research is necessary, it is possible that this type of dissociation is associated with people paying less attention to incoming activity, and therefore failing to process the information in a normative way. This could translate into difficulty with event segmentation, as this task requires people to pay constant attention to stimuli and continuously process the events occurring within the movies. The PDEQ also asks about experiences similar to these, and it is therefore surprising that it does not also predict segmentation agreement. One possibility for this finding may be that because the PDEQ only asks about experiences at the time of the traumatic event, it does not capture processes that are still present at the time of testing. In addition, the PDEQ is a retrospective measure that assumes participants have a veridical memory for their experiences during their traumatic event. It is therefore possible that scores on the PDEQ gathered closer to the time of the traumatic would predict later performance on event segmentation tasks. Furthermore, it is unclear why scores on the DES fail to predict event memory. People who display difficulty with processing incoming information would also be expected to have greater difficulty remembering this information. As discussed above

for PTSD symptom severity, it is possible that the participants in this sample do not display dissociation that is severe enough to affect memory. Future research with populations with more severe dissociative symptoms could help elucidate these results.

*Perceived Social Support, Segmentation Agreement, and Event Memory.* The results of this study suggest that level of perceived social support predicts both segmentation agreement and event memory after controlling for PTSD symptom severity. Consistent with previous studies, level of perceived social support also was significantly correlated with PTSD symptom severity. However, the interaction between perceived level of social support and PTSD symptom severity did not explain significant variance in segmentation agreement, meaning that having both high PTSD and low social support is not associated with significantly less normative segmentation agreement than the main effects suggest on their own.

These findings are surprising because it is unclear why perceived social support should relate to segmentation agreement and event memory independently of PTSD symptom severity, particularly because the movies used in this study involved single actors who did not engage in any explicit social interactions. Though there are few studies that have examined the relationship between social support and memory, Lakey & Cassady (1990) found that higher levels of perceived social support predicted better memory for positive supportive behaviors. In addition, Mueser, Bellack, Douglas, & Wade (1991) found that worse memory predicted pretreatment social skill impairments in patients with schizophrenia and schizoaffective disorder, but not affective disorder, providing some evidence for a relationship between memory and social support. In addition, Stiller & Dunbar (2007) suggest that maintaining a social network requires

maintaining and updating a constantly shifting mental representation of relationships between individuals, which clearly involves memory. In this study, participants heard seven short stories that involved social situations and were then required to answer questions testing their memory for the stories. They found that memory for the stories significantly predicted the size of participants' primary social network (individuals participants contacted at least once a month).

The present study adds to the literature on social support and memory and suggests that social support also predicts memory for activities that are not explicitly social. It is possible that people who are less normative in their ability to segment non-social activity into meaningful events have the same difficulty segmenting social activity into meaningful units. These people might therefore have worse memory for social relationships, leading to a smaller social network and less perceived social support. Alternatively, it is possible that engaging in numerous social interactions allows people to practice segmenting information in a context where they can also compare their interpretations of events with those of others, helping them to become more normative in their segmentation. Further research is necessary to provide support for these hypotheses.

Overall, this study provides support for our hypothesis that PTSD predicts event segmentation agreement, meaning that people with higher severity of PTSD symptoms are less normative in their placement of event boundaries. In addition, trait dissociation predicts segmentation agreement, implying that dissociation may hamper people's ability to process incoming information. Finally, level of perceived social support predicts both segmentation agreement and event memory, suggesting that people's processing and

memory of ongoing activity may influence the size of their social networks and therefore their perception of their available social support.



## References

- American Psychiatric Association: *Diagnostic and Statistical Manual of Mental Disorders*, Fourth Edition, Text Revision. Washington, DC, American Psychiatric Association, 2000.
- Armitage, S. G. (1946). An analysis of certain psychological tests used for the evaluation of brain injury. *Psychological Monographs*, 60(1), i-48.
- Bernstein, E. M. & Putnam, F. W. (1986). Development, reliability, and validity of a dissociation scale. *Journal of Nervous and Mental Disease*, 174(12), 727-735.
- Birmes, P., Brunet, A., Carreras, D., Ducassé, J. L., Charlet, J. P., Lauque, D., Sztulman, H., & Schmitt, L. (2003). The predictive power of peritraumatic dissociation and acute stress symptoms for posttraumatic stress symptoms: A three-month prospective study. *The American Journal of Psychiatry*, 160(7), 13337-13339.
- Blake, D. D., Keane, T. M., Wine, P. R., Mora, C., Taylor, K. L., & Lyons, J. A. (1990). Prevalence of PTSD symptoms in combat veterans seeking medical treatment. *Journal of Traumatic Stress*, 3(1), 15-27.
- Bremner, D. J., Narayan, M., Staib, L., 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. *The American Journal of Psychiatry*, 156(11), 1787-1795.
- Bremner, J. D., Southwick, S., Brett, E., Fontana, A., Rosenheck, R., & Charney, D. S. (1992). Dissociation and posttraumatic stress disorder in Vietnam combat veterans. *The American Journal of Psychiatry*, 149(3), 328-332.

- Bremner, D. J., Staib, L. H., Kaloupek, D., Southwick, S. M., Soufer, R., & 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.
- Bremner, D. J., Vermetten, E., Vythilingam, M., Afzal, N., Schmahl, C., Elzinga, B., & Charney, D. S. (2004). Neural correlates of the classic color and emotional stroop in women with abuse-related posttraumatic stress disorder. *Biological Psychiatry, 55*, 612-620.
- Breslau, N., Chilcoat, H. D., Kessler, R. C., & Davis, G. C. (1999). Previous exposure to trauma and PTSD effects of subsequent trauma: Results from the Detroit area survey of trauma. *The American Journal of Psychiatry, 156*, 902-907.
- Britton, J. C., Phan, K. L., Taylor, S. F., Fig, L. M., & Liberzon, I. (2005). Corticolimbic blood flow in posttraumatic stress disorder during script driven imagery. *Biological Psychiatry, 57*, 832-840.
- Brown, J. W. & Braver, T. S. (2005). Learned predictions of error likelihood in the anterior cingulate cortex. *Science, 307*, 1118-1121.
- Bryant, R. A., Felmingham, K. L., Kemp, A. H., Barton, M., Peduto, A. S., Renni, C., . . . Williams, L. M. (2005). Neural networks of information processing in posttraumatic stress disorder: A functional magnetic resonance imaging study. *Biological Psychiatry, 58*, 111-118.
- Buschke, H. (1984). Cued recall in amnesia. *Journal of Clinical Neuropsychology, 6*(4), 433-440.

- Bush, G., Luu, P., & Posner, M. I. (2000). Cognitive and emotional influences in anterior cingulate cortex. *Trends in Cognitive Sciences*, 4(6), 215-222.
- Chen, J., Hale, S., & Myerson, J. (2007). Predicting the size of individual and group differences on speeded cognitive tasks. *Psychonomic Bulletin and Review*, 14(3), 534-541.
- Cohen, J. D., MacWhinney, B., Flatt, M., & Provost, J. (1993). PsyScope: An interactive graphic system for designing and controlling experiments in the psychology laboratory using Macintosh computers. *Behavior Research Methods, Instruments, and Computers*, 25(2), 257-271.
- Connely, S. L., Hasher, L., & Zacks, R. T. (1991). Age and reading: The impact of distraction. *Psychology and Aging*, 6(4), 533-541.
- Creamer, M., McFarlane, A. C., & Burgess, P. (2005). Psychopathology following trauma: The role of subjective experience. *Journal of Affective Disorders*, 86, 175-182.
- Dixon, R. A. & de Frias, C. M. (2004). The Victoria Longitudinal Study: From characterizing cognitive aging to illustrating changes in memory compensation. *Aging Neuropsychology and Cognition*, 11(2-3), 346-376.
- Felmingham, K. L., Williams, L. M., Kemp, A. H., Rennie, C., Gordan, E., & Bryant, R. A. (2009). Anterior cingulate activity to salient stimuli is modulated by autonomic arousal in posttraumatic stress disorder. *Psychiatry Research: Neuroimaging*, 173, 59-62.

- Frans, Ö, Rimmö, P. A., Åberg, L., & Fredrikson, M. (2005). Trauma exposure and post-traumatic stress disorder in the general population. *ACTA Psychiatrica Scandinavica, 111*, 291-299.
- Fronzo, G. A., Simmons, A. N., Thorp, S. R., Norman, S. B., Paulus, M. P. & Stein, M. B. (2010). Exaggerated and disconnected insular-amygdalar blood oxygenation level-dependent response to threat-related emotional faces in women with intimate-partner violence posttraumatic stress disorder. *Biological Psychiatry, 68*, 433-441.
- Galvin, J. E., Roe, C. M., Coats, M. A., & Morris, J. C. (2007). Patient's rating of cognitive ability. *Archives of Neurology, 64*, 725-730.
- Gil, T., Caley, A. Greenberg, D., Kugelmass, S., & Lerer, B. (1990). Cognitive functioning in post-traumatic stress disorder. *Journal of Traumatic Stress, 3*(1), 29-45.
- Gilbertson, M. W., Gurvits, T. V., Lasko, N. B., Orr, S. P., & Pitman, R. K. (2001). Multivariate assessment of explicit memory function in combat veterans with posttraumatic stress disorder. *Journal of Traumatic Stress, 14*(2), 413-432.
- Goldberg, L. R., Johnson, J. A., Eber, H. W., Hogan, R., Ashton, M. C., Cloninger, C. R., & Gough, H. G. (2006). The international personality item pool and the future of public-domain personality measures. *Journal of Research in Personality, 40*, 84-96.
- Holeva, V., Tarrier, N., & Wells, A. (2001). Prevalence and predictors of acute stress disorder and PTSD following road traffic accidents: Thought control strategies and social support. *Behavior Therapy, 32*(1), 65-83.

- Holroyd, C. B., Nieuwenhuis, S., Yeung, N., Nystrom, L., Mars, R. B., Coles, M. G. H., & Cohen, J. D. (2004). Dorsal anterior cingulate cortex shows fMRI response to internal and external error signals. *Nature Neuroscience*, *7*(5), 497-498.
- Horne, J. A. & Ostberg, O. (1976). A self-assessment questionnaire to determine morningness and eveningness in human circadian rhythms. *International Journal of Chronobiology*, *4*(2), 97-110.
- Hyman, S. M., Gold, S. N., & Cott, M. A. (2003). Forms of social support that moderate PTSD in childhood sexual abuse survivors. *Journal of Family Violence*, *18*(5), 295-300.
- van Ijzendoorn, M. H. & Schuengel, C. (1996). The measurement of dissociation in normal and clinical populations: Meta-analytic validation of the dissociative experiences scale (DES). *Clinical Psychology Review*, *16*(5), 365-382.
- Jenkins, M. A., Langlais, P. J., Delis, D., & Cohen, R. (1998). Learning and memory in rape victims with posttraumatic stress disorder. *The American Journal of Psychiatry*, *155*(2), 278-279.
- Jenkins, M. A., Langlais, P. J., Delis, D., & Cohen, R. (2000). Attentional dysfunction associated with posttraumatic stress disorder among rape survivors. *The Clinical Neuropsychologist*, *14*(1), 7-12.
- Kane, M., Brown, L. H., McVay, J. C., Silvia, P. J., Myin-Germeys, I., & Kwapil, T. R. (2007). For whom the mind wanders, and when: An experience sampling study of working memory and executive control in daily life. *Psychological Science*, *18*(7), 614-621.

- Keane, T. M., Scott, W. O., Chavoya, G. A., Lamparski, D. M., & Fairbank, J. A. (1985). Social support in Vietnam veterans with posttraumatic stress disorder: A comparative analysis. *Journal of Consulting and Clinical Psychology, 53*(1), 95-102.
- Kessler, R. C., Berglund, P., Demler, O., Jin, R., Merikangas, K. R., & Walters, E. E. (2005). Lifetime prevalence and age-of-onset distribution of DSM-IV disorders in the national comorbidity survey replication. *Archives of General Psychiatry, 62*, 593-602.
- Kubany, E. S., Haynes, S. N., Leisen, M. B., Owens, J. A., Kaplan, A. S., Watson, S. B., & Burns, K. (2000). Development and preliminary validation of a brief broad-spectrum measure of trauma exposure: The traumatic life events questionnaire. *Psychological Assessment, 12*(2), 210-224.
- Kubany, E. S., Leisen, M. B., Kaplan, A. S., & Kelly, M. P. (2000). Validation of a brief measure of posttraumatic stress disorder: The distressing events questionnaire (DEQ). *Psychological Assessment, 12*(2), 197-209.
- Lakey, B. & Cassady, P. B. (1990). Cognitive processes in perceived social support. *Personality and Social Psychology, 59*(2), 337-343.
- Lindem, K., Heeren, T., White, R. F., Proctor, S. P., Krenzel, M. Vasterling, J., Sutker, P. B., Wolfe, J., & Keane, T. M. (2003). Neuropsychological performance in Gulf War era veterans: Traumatic stress symptomatology and exposure to chemical-biological warfare agents. *Journal of Psychopathology and Behavioral Assessment, 25*(2), 105-119.

- Marmar, C. R., Weiss, D. S., & Metzler, T. J. (1998). Peritraumatic dissociation and posttraumatic stress disorder. In J. D. Bremner & C. R. Marmar (Eds.), *Trauma, memory, and dissociation* (pp. 229-252). Washington, DC: American Psychiatric Association.
- Marmar, C. R., Weiss, D. S., Schlenger, W. E., Fairbank, J. A., Jordan, K., Kulka, R. A., & Hough, R. L. (1994). Peritraumatic dissociation and posttraumatic stress in male Vietnam Theater veterans. *The American Journal of Psychiatry*, *151*(6), 902-907.
- Marshall, G. N., Orlando, M., Jaycox, L. H., Foy, D. W., & Belzberg, H. (2002). Development and validation of a modified version of the peritraumatic dissociative experiences questionnaire. *Psychological Assessment* *14*(2), 123-134.
- Morris, J. C., Heyman, A., Mohs, R. C., Hughes, J. P., van Belle, G., Fillenbaum, G., . . . Clark, C. (1989). The consortium to establish a registry for Alzheimer's disease (CERAD). Part I. Clinical and neuropsychological assessment of Alzheimer's disease. *Neurology*, *39*(9), 1159-1165.
- Mueser, K. T., Bellack, A. S., Douglas, M. S., & Wade, J. H. (1991). Prediction of social skill acquisition in schizophrenia and major affective disorder patients from memory and symptomatology. *Psychiatry Research*, *37*(3), 281-296.
- Newton, D. & Engquist, G. (1976). The perceptual organization of ongoing behavior. *Journal of Experimental and Social Psychology*, *12*(5), 436-450.
- Rosen, V. M., Caplan, L., Sheesley, L., Rodriguez, R., & Grafman, J. (2003). An examination of daily activities and their scripts across the adult lifespan. *Behavior Research Methods, Instruments, and Computers*, *35*(1), 32-48.

- Rothbaum, B. O., Foa, E. B., Riggs, D. S., Murdock, T., & Walsh, W. (1992). A prospective examination of post-traumatic stress disorder in rape victims. *Journal of Traumatic Stress, 5*(3), 455-475.
- Ruff, R. M., Light, R. H., & Evans, R. W. (1987). The Ruff figural fluency test: A normative study with adults. *Developmental Neuropsychology, 3*(1), 37-51.
- Salthouse, T. A. (1993). Speed and knowledge as determinants of adult age differences in verbal tasks. *Journal of Gerontology: Psychological Sciences, 48*(1), P29-P36.
- Salthouse, T. A. & Babcock, R. L. (1991). Decomposing age differences in working memory. *Developmental Psychology, 27*(5), 763-776.
- Sargent, J. Q., Zacks, J. M., Hambrick, D. Z., Zacks, R. T., Kurby, C. A., Bailey, H., . . . Beck, T. M. *Event Segmentation Ability Uniquely Predicts Memory Across the Lifespan*. Unpublished Manuscript.
- Schwan, S., Garsoffky, B., & Hesse, F. W. (2000). Do film cuts facilitate the perceptual and cognitive organization of activity sequences? *Memory and Cognition, 28*(2), 214-223.
- Schwartz, M. F. (1991). The quantitative description of action disorganization after brain damage: A case study. *Cognitive Neuropsychology, 8*(5), 381-414.
- Shalev, A. Y., Peri, T., Canetti, L., & Schreiber, S. (1996). Predictors of PTSD in injured trauma survivors: A prospective study. *The American Journal of Psychiatry, 153*(2), 219-225.
- Shin, L. M., Lasko, N. B., Macklin, B. A., Karpf, R. D., Milad, M. R., Orr, S. P., . . . Pitman, R. K. (2009). Resting metabolic activity in the cingulate cortex and



- vulnerability to posttraumatic stress disorder. *Archives of General Psychiatry*, *66(10)*, 1099-1107.
- Shin, L. M., Whalen, P. J., Pitman, R. K., Bush, G., Macklin, M. L., Lasko, N. B., . . . Rauch, S. L. (2001). An fMRI study of anterior cingulate function in posttraumatic stress disorder. *Society of Biological Psychiatry*, *50*, 932-942.
- Solomon, Z., Mikulincer, M., & Avitzur, E. (1988). Coping, locus of control, social support, and combat-related posttraumatic stress disorder: A prospective study. *Journal of Personality and Social Psychology*, *55(2)*, 279-285.
- Speer, N. K. & Zacks, J. M. (2005). Temporal changes as event boundaries: Processing and memory consequences of narrative time shifts. *Journal of Memory and Language*, *53(1)*, 125-140.
- Stiller, J. & Dunbar, R. I. M. (2007). Perspective-taking and memory capacity predict social network size. *Social Networks*, *29*, 93-104.
- Swallow, K. M., Zacks, J. M., & Abrams, R. A. (2009). Event boundaries in perception affect memory encoding and updating. *Journal of Experimental Psychology: General*, *138(2)*, 236-257.
- Tichenor, V, Marmar, C. R., Weiss, D. S., Metzler, T. J., & Ronfeldt, H. M. (1996). The relationship between dissociation and posttraumatic stress: Findings in female Vietnam Theater veterans. *Journal of Consulting and Clinical Psychology*, *64(5)*, 1054-1059.
- Unsworth, N., Heitz, R. P., Schrock, J. C., Engle, R. W. (2005). An automated version of the operation span task. *Behavior Research Methods*, *37(3)*, 498-505.

- Vasterling, J. J., Brailey, K., Constans, J. I., & Sutker, P. B. (1998). Attention and memory dysfunction in posttraumatic stress disorder. *Neuropsychology, 12*(1), 125-133.
- Vasterling, J. J., Duke, L. M., Brailey, K., Constans, J. I., Allain, Jr., A. N., & Sutker, P. B. (2002). Attention, learning, and memory performance and intellectual resources in Vietnam veterans: PTSD and no disorder comparisons. *Neuropsychology, 16*(1), 5-14.
- van Veen, V., Cohen, J. D., Botvinick, M. M., Stenger, V. A., & Carter, C. S. (2001). Anterior cingulate cortex, conflict monitoring, and levels of processing. *Neuroimage, 14*, 1302-1308.
- Wechsler, D. (1997). *WAIS-III: Wechsler Adult Intelligence Scale* (3rd ed.). San Antonio, TX: The Psychological Corporation.
- Weiss, D. S., Marmar, C. R., Schlenger, W.E., Fairbank, J. A., Jordan, B. K., Hough, R. L., & Kulka, R. A. (1992). The prevalence of lifetime and partial post-traumatic stress disorder in Vietnam theater veterans. *Journal of Traumatic Stress, 5*(3), 365-376.
- Yehuda, R., Keefe, R. S. E., Harvey, P. D., Levengood, R. A., Gerber, D. K., Geni, J., & Siever, L. J. (1995). Learning and memory in combat veterans with posttraumatic stress disorder. *The American Journal of Psychiatry, 152*(1), 137-139.
- Zacks, J. M., Braver, T. S., Sheridan, M. A., Donaldson, D. I., Snyder, A. Z., Ollinger, J. M., . . . Raichle, M. E. (2001). Human brain activity time-locked to perceptual event boundaries. *Nature Neuroscience, 4*, 651-655.

Zacks, J. M., Speer, N. K., Swallow, K. M., Braver, T. S., & Reynolds, J. R. (2007).

Event Perception: A mind-brain perspective. *Psychological Bulletin*, 133(2), 273-293.

Zacks, J. M., Speer, N. K., Vettel, J. M., & Jacoby, L. L. (2006). Event understanding and memory in healthy aging and dementia of the Alzheimer type. *Psychology and Aging*, 21(3), 466-482.

Zimet, G. D., Dahlem, N. W., Zimet, S. G., & Farley, G. K. (1988). The multidimensional scale of perceived social support. *Journal of Personality Assessment*, 52(1), 30-41.

Tables and Figures:

<b>PTSD and Associated Measures</b>	<b>Mean</b>	<b>SD</b>	<b>Skew</b>	<b>Kurtosis</b>
PSDS	12.54	14.83	1.36	1.02
PDEQ	18.8	9.06	1.1	0.476
DES	23.83	25.83	2.73	10.72
MSPSS	62.84	17.61	-1.06	0.63

**Table 1: Descriptive Statistics for PTSD and Associated Measures.** PSDS = PTSD Screening and Diagnostic Scale; PDEQ = Peritraumatic Dissociative Experiences Questionnaire; DES: Dissociative Experiences Scale; MSPSS = Multidimensional Scale of Perceived Social Support.

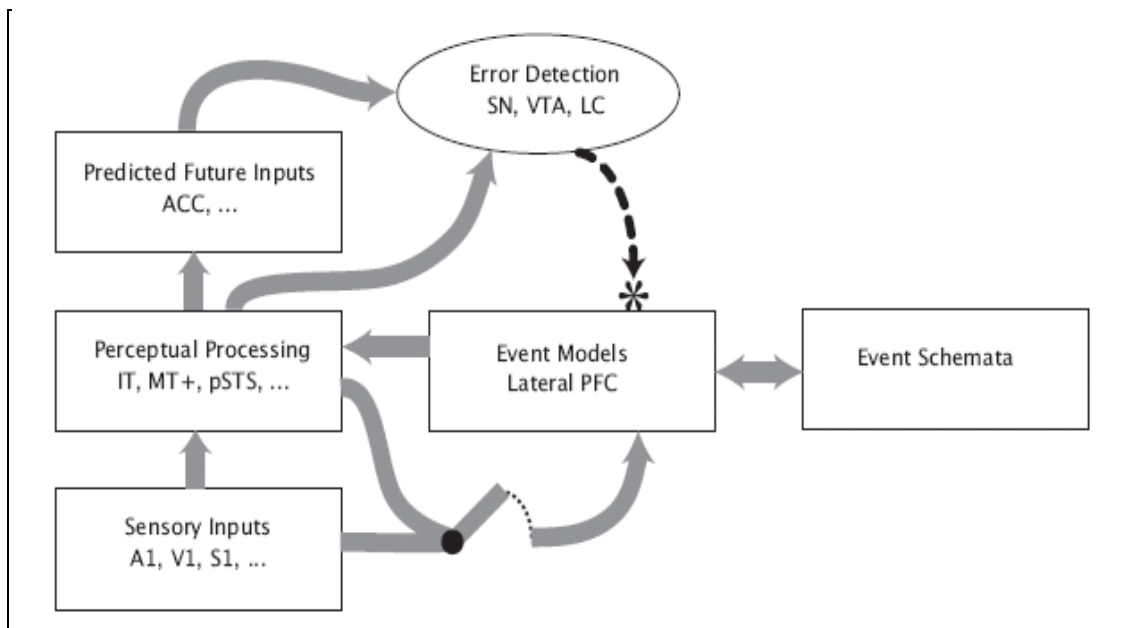
<b>Constructs and Measures</b>	<b>Mean</b>	<b>SD</b>	<b>Skew</b>	<b>Kurtosis</b>
<b>Working Memory:</b>				
Reading Span	20.84	6.00	-1.01	0.58
Operation Span	19.95	6.99	-0.78	-0.592
Symmetry Span	12.30	6.51	0.24	-0.71
<b>Laboratory Episodic Memory:</b>				
Selective Reminding:	46.92	6.93	-0.22	-0.39
Verbal Paired Associates	18.13	3.98	-0.45	-0.46
Word List Recall	18.10	5.55	-0.46	-0.18
<b>Executive Function:</b>				
Reading with Distraction	0.48	0.24	1.41	3.06
Trail Making	1.33	0.74	1.26	2.73
Ruff Figural Fluency	74.39	24.54	0.209	-0.36
<b>Processing Speed:</b>				
Shape Comparison	0.99	0.27	0.72	0.88
Letter Comparison	7.14	1.91	0.57	0.24
Pattern Comparison	12.78	2.78	0.52	0.32
<b>General Knowledge:</b>				
Information Test	18.69	5.28	-0.69	-0.23
Synonym Vocabulary	0.57	0.29	-0.10	-1.02
Antonym Vocabulary	0.55	0.29	-0.06	-1.07
Event Memory	27.68	11.65	0.33	0.02
Segmentation Agreement <sup>‡</sup>	0.60	0.08	-1.00	2.01
Education (years)	14.90	2.53	-0.28	-0.10

**Table 2: Descriptive Statistics for Composite Measures.** Mean scores are proportion correct except: Span scores are total number of items correct on trials with correct response on processing task; Reading with Distraction = (low distraction – high distraction)/(low distraction) reading times; Trail Making = (B – A)/A time to completion; Ruff = total unique designs; Letter and Pattern Comparison are total number of items completed in 20 seconds; and Shape Comparison is the average time in seconds to complete 1 trial .

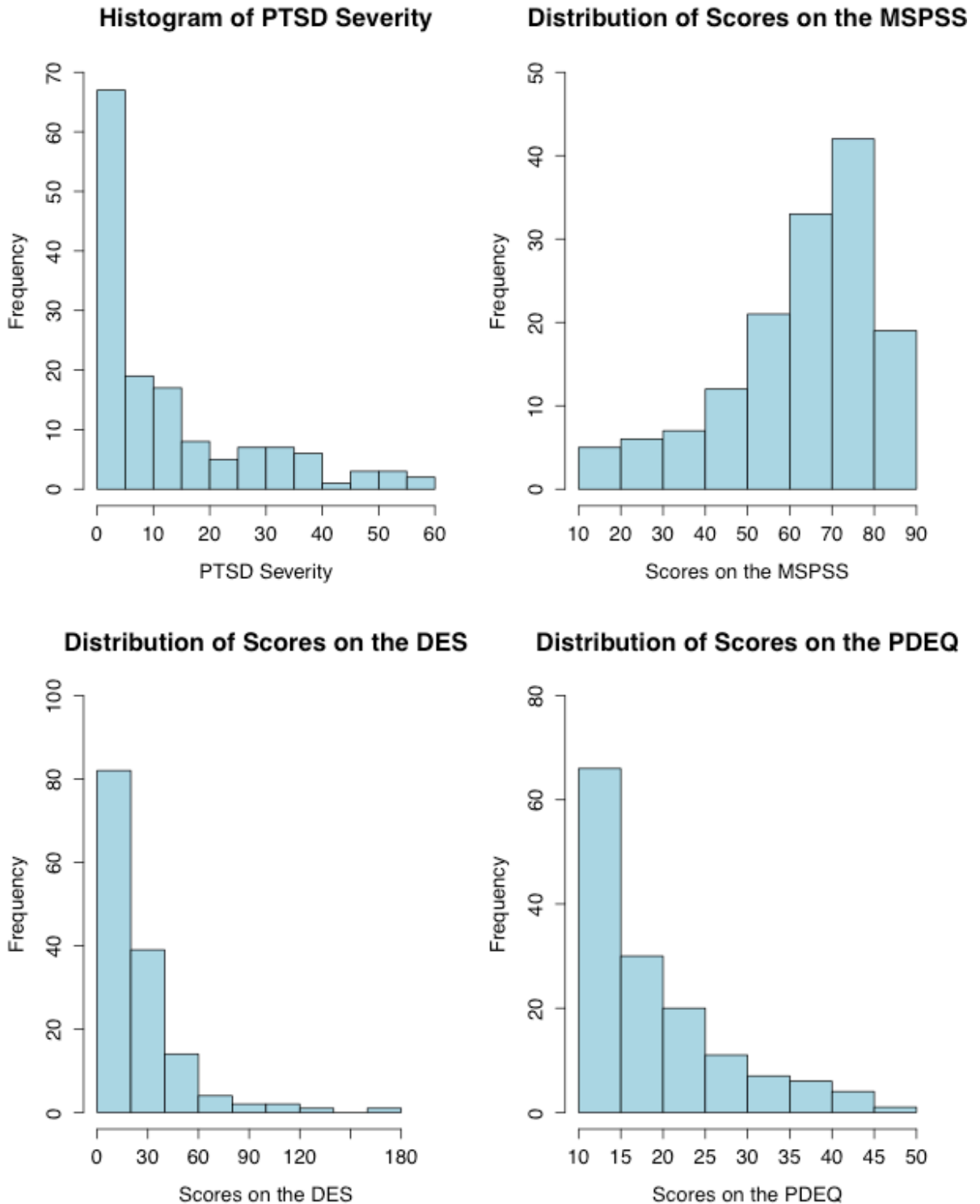
‡ When the outlier is removed, the distribution has skew = -0.585 and kurtosis = 0.085.

Composite Variables	PTSD Severity	
	r	p
Working Memory	-0.105	0.208
Verbal Episodic Memory	-0.068	0.419
General Knowledge	-0.181	0.030
Processing Speed	-0.043	0.607

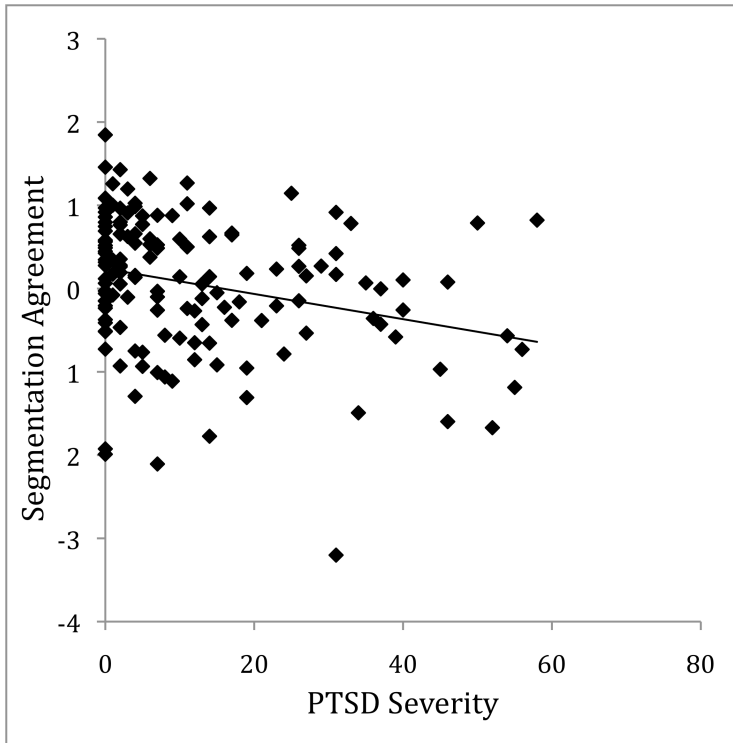
**Table 3.** Correlation Coefficients and Significance Tests Between PTSD Symptom Severity and the Four Composite Variables



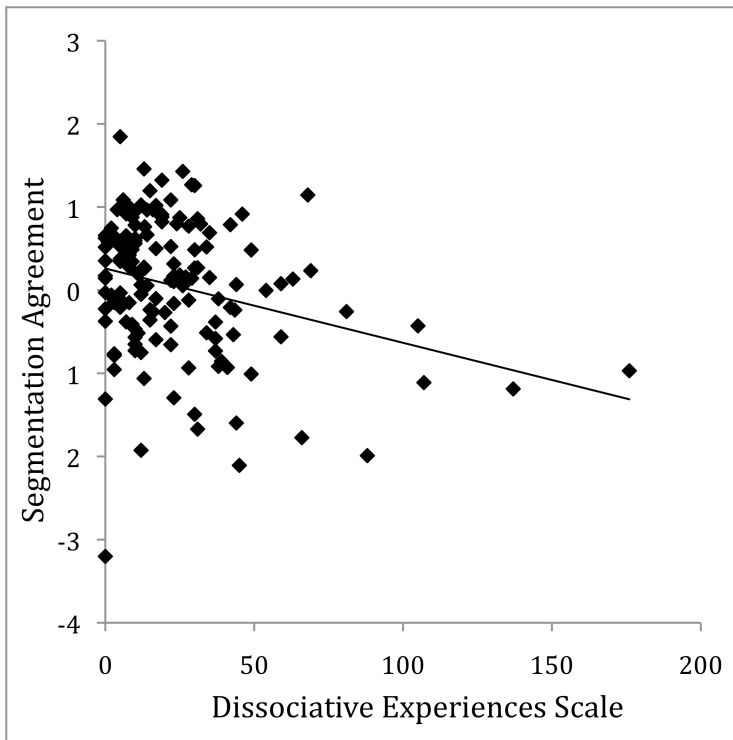
**Figure 1.** Schematic depiction of *Event Segmentation Theory*. From Zacks et al. (2007).



**Figure 2: Distributions of scores on the PSDS, MSPSS, DES, and PDEQ.** All four of these distributions are clearly non-normally distributed. Although the residual distributions were normally distributed and homoschedastic, we conducted permutation analyses in addition to parametric analyses to ascertain the robustness of our findings.

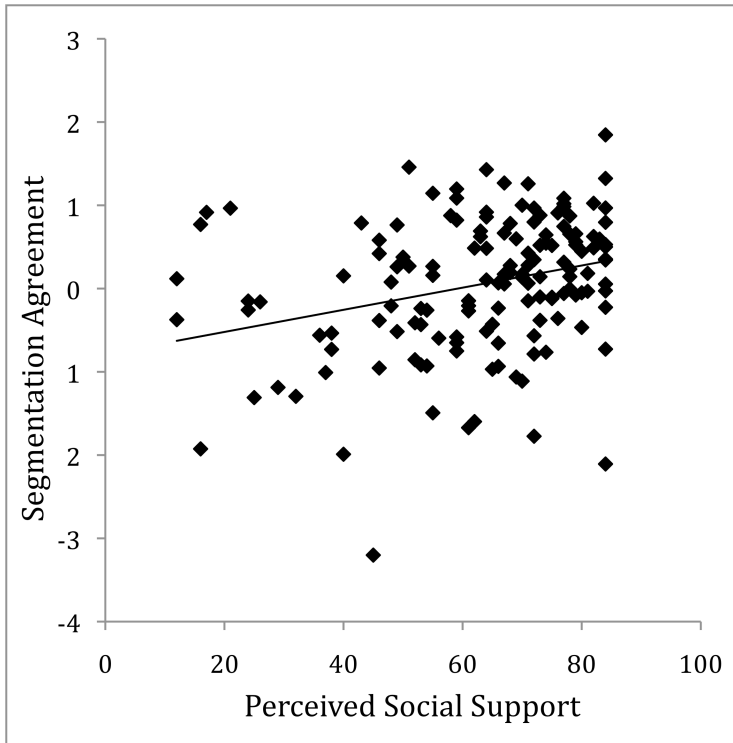


**Figure 3.** PTSD symptom severity was significantly correlated with segmentation agreement ( $r = -0.27, p < .05$ ).

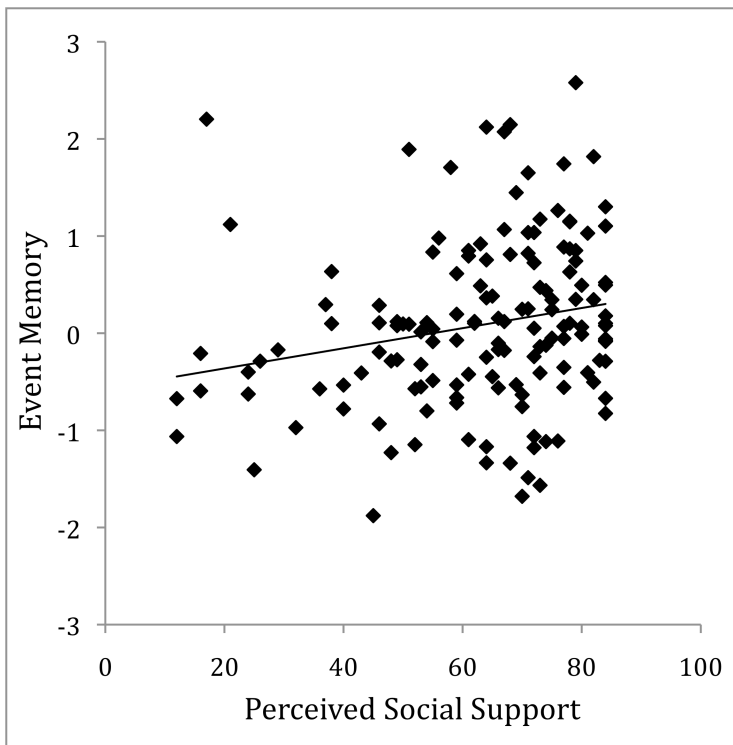


**Figure 4.** Scores on the Dissociative Experiences Scale were significantly correlated with segmentation agreement ( $r = -0.259, p < .05$ ).





**Figure 5.** Scores on the Multidimensional Scale of Perceived Social Support were significantly correlated with segmentation agreement ( $r = 0.280$ ,  $p < .05$ ).



**Figure 6.** Scores on the Multidimensional Scale of Perceived Social Support were significantly correlated with event memory ( $r = 0.210$ ,  $p < .05$ ).