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ORIGINAL RESEARCH REPORT

Posttraumatic Stress and the Comprehension of Everyday Activity

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People with Posttraumatic Stress Disorder (PTSD) often report difficulties with attention and memory on tasks that are unrelated to their trauma. One important component of everyday event comprehension is the segmentation of ongoing activity into meaningful events. The present study asked whether PTSD symptom severity was associated with impaired segmentation and memory for neutral, ongoing activity. A sample of 137 participants, ages 21–79, completed event segmentation and memory tasks, general cognitive functioning tasks, and questionnaires assessing PTSD symptom severity. People with higher levels of PTSD symptoms had poorer event segmentation and event memory performance. Hierarchical multiple regression analyses demonstrated that PTSD symptom severity explained unique variance in event segmentation performance, even after controlling for general cognitive function. These results suggest that interventions aimed at improving event comprehension may help compensate for memory disruptions in PTSD.

Keywords: Event Cognition; Posttraumatic Stress; Perception; Memory

Posttraumatic Stress Disorder (PTSD) is a disabling disorder with a lifetime prevalence of 6.8% in the United States [1]. 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; [2]). People with PTSD also often report impairments in attention and memory on tasks that are not directly related to their traumatic event, such as difficulty remembering a phone number or following a conversation. 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 [3]. However, we know of no research on how people with symptoms of PTSD comprehend and remember everyday events. The present study therefore asked whether PTSD symptom severity is negatively associated with comprehension and memory of ongoing, naturalistic activity.

Hypervigilance, one of the symptoms of increased arousal, may have a particular influence on the way people perceive ongoing activity during everyday life. Hypervigilance results in a state of alertness focused on identifying potentially threatening stimuli [3]. Though hypervigilance can be extremely disruptive for people with PTSD, it is maintained because people with PTSD believe constant alertness will prevent them from experiencing future traumatic events [4]. This may be a normal and adaptive response immediately after a traumatic experience, when threats may still linger [5]; however, when constant alertness continues long after the trauma, as it does in PTSD, it likely adversely impacts people's perception of non-threatening information. For example, the loud noise of a door closing might trigger a combat veteran to take cover because the door's sound is similar to the sound of a bomb exploding. This type of reaction could severely impact the way people perceive, comprehend, and remember ongoing activity, even activity unrelated to their traumatic event.

Though people with PTSD may be hyper-attentive to components of the environment that are reminiscent of their traumatic event, this likely comes at a cost to their ability to pay attention to other features of the environment. In fact, there has been some research suggesting that symptoms of PTSD affect the processing of non-trauma related information, though these studies have not included ongoing, naturalistic stimuli. Many of these studies examined event-related potentials (ERPs), including the P300 response (associated with an enhancement of attention to stimuli; see [6] for a review of the P300), to determine how PTSD symptoms affect responses to unexpected auditory tones, words, and pictures. For example, in a meta-analysis of ERP studies in people with PTSD, Karl, Malta, and Maercker [7] found evidence suggesting that people with PTSD displayed reduced arousal in response to neutral information (reduced P300 response) but increased arousal in response to both

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trauma-related and neutral information presented in the context of trauma-related information (increased P300 response). In another study, people with PTSD showed an increased P300 response to completely novel but neutral auditory stimuli, though not to rare stimuli that repeated throughout the task [8]. Because the novel stimuli used in this study were unpredictable (rare stimuli that repeated over the course of a task were more predictable than completely novel stimuli), this study suggests that people with PTSD react with hypervigilance to unpredicted novel stimuli, even when those stimuli are not inherently threatening. The results of these studies suggest that this constant alertness could disrupt people's comprehension of non-trauma related ongoing activity.

Adaptive comprehension of ongoing activity requires people to parse information into meaningful units, and *event segmentation* is a normal part of everyday perception that people engage in without conscious effort (see [9] for a review). For example, when watching a friend make lunch, one might perceive the activity as consisting of events such as taking ingredients out of the refrigerator, slicing bread and cheese, assembling sandwiches, and so forth. Event segmentation can be studied in the laboratory by asking participants to watch movies of everyday activities and to push a button whenever they believe a meaningful unit of activity has ended and another has begun [10]. Failure to segment ongoing activity adaptively is associated with poorer subsequent memory [11, 12, 13]. Thus, event segmentation provides a method to assess cognitive impairment in people with symptoms of PTSD, and to ask whether deficits in comprehension are associated with deficits in subsequent memory. If so, this would suggest potential points for intervention to address these deficits.

Although there are binary classification criteria for clinical PTSD, many people who are subject to trauma but do not meet full PTSD criteria experience some symptoms of PTSD and display decreased performance on cognitive tasks that falls between that of people without any symptoms of PTSD and that of people with clinical levels of PTSD (e.g., [14, 15]). Thus, there is good reason to think that people with higher PTSD symptom severity who do not meet full criteria for PTSD would experience difficulty with event comprehension and memory, though perhaps to a lesser degree. Therefore, the present study included participants with a wide range of PTSD severity scores.

In the present study, participants completed event segmentation and event memory tasks. They also completed tasks assessing general cognitive functioning, including working memory, episodic memory, executive function, general knowledge, and processing speed tasks. In addition, participants completed self-report questionnaires measuring symptoms of PTSD. We hypothesized that, after controlling for general cognitive functioning, PTSD symptom severity would explain unique variance in performance on event segmentation and event memory tasks. In addition, we hypothesized that symptoms of increased arousal, including hypervigilance, would predict performance on event segmentation and event memory tasks.

Method

Participants

Participants were recruited immediately after their participation in a cross-sectional study of the relationship between age, cognitive ability, and event segmentation [12]. Two hundred eight adults from the Sargent et al. [12] study were given the option to participate in this study and complete a packet of PTSD questionnaires at home. Sargent et al. [12] recruited these participants from the Volunteer for Health participant registry at the Washington University School of Medicine. Participants received $10 for participating in the study. Of the 208 adults who completed the cross-sectional study, 137 participants correctly completed and returned the questionnaires (51% female; 72% White; mean age = 50 years, age range 20–79, 18–28 participants in each decade; mean years of education = 15.1), and data from these 137 participants were included in all of the below analyses. The study received approval from the Washington University Human Resources Protection Office and participants provided written informed consent before participating in this study.

The mean age of those who declined to participate did not differ from that of participants, $t(231) = -0.723$, $p = 0.42$. Five participants did not provide their level of education, and these data were therefore imputed using data from the non-PTSD-related measures of the 208 participants who completed the cross-sectional study using the expectation maximization (EM) procedure in SPSS 19.0. Sixteen of those participants who declined to participate did not provide their level of education and did not provide enough other data for this information to be imputed; however, for the data available, mean levels of education differed between the included (mean = 15.1 years, sd = 2.5) and excluded (mean = 14.1, sd =2.7) participants; $t(215) = 2.76$, $p = .006$.

Event Segmentation and Event Memory Variables

The event segmentation task required participants to view three movies of everyday activities and push a button whenever they believed "one natural and meaningful unit of activity has ended and another has begun." Each of the movies depicted an actor completing a neutral, everyday activity (making breakfast, preparing for a party, and gardening). The order of movie presentation was fixed across participants. The movies were filmed from a fixed, head-height perspective, with no zoom, and the movies ranged in length from 329 seconds to 376 seconds. Participants segmented each movie twice: at a coarse grain (push the button whenever you believe one large natural and meaningful unit of activity has ended and another has begun) and at a fine grain (push the button whenever you believe one small natural and meaningful unit of activity has ended and another has begun).

Performance on the event segmentation task was measured by calculating a segmentation agreement score for each participant. Segmentation agreement is a measure of the similarity between each participant's segmentation and the segmentation of the group as a whole, and it was calculated using the methods provided in Kurby and Zacks [16]. First, time in each of the movies was divided into one-second bins. Then, the group norms for fine and coarse segmentation were calculated by determining the proportion of participants who identified an event boundary within each bin. Coarse and fine segmentation agreement scores for each participant were generated by correlating each participant's coarse segmentation with the coarse group norm and each participants' fine segmentation with the fine group norm, and scaling the resulting correlations to 0–1 variables based on the maximum and minimum correlation possible given how many boundaries each participant identified. Finally, segmentation agreement scores for fine and coarse segmentation were averaged to obtain a final segmentation agreement score for each participant[1].

Following the first viewing of each movie, participants completed a recall task, for which they were given seven minutes to write or type as much as they could remember from the movie. Recall was scored using methods similar to those described in Schwartz [17]. Three experimenters independently viewed each movie and listed every meaningful action performed by the actor in the movie. Each meaningful action agreed upon by the three experimenters was then included in the scoring template. 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, inter-rater kappa = 0.84, $p < .001$, 95% CI [0.78, 0.90].

Cognitive Functioning Variables

Participants also completed a psychometric battery that included three tasks in each of five domains of cognitive function: working memory (reading span, operation span, and symmetry span), laboratory episodic memory (selective reminding, verbal paired associates, and word list recall), executive function (reading with distraction, trail making, and Ruff figural fluency), processing speed (shape completion, letter comparison, and pattern completion), and general knowledge (information test, synonym vocabulary, and antonym vocabulary). (The event comprehension and psychometric measures were completed as part of the Sargent et al. [12] study, and are described in more detail in that paper.)

PTSD Measures

Participants completed a packet of questionnaires that included the Traumatic Life Events Questionnaire (TLEQ; [18]) and the PTSD Screening and Diagnostic Scale (PSDS[2]; [19]). The TLEQ is designed to determine exposure to twenty-two types of potentially 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 most traumatic event they indicated on the TLEQ. Participants were instructed to complete the PSDS even if they indicated that they had not experienced any traumatic events. The PSDS is a thirty-eight item questionnaire designed to assess severity of PTSD symptoms based on DSM-IV criteria. It has high internal consistency ($\alpha = 0.93$), test-retest reliability ($r = .95$), sensitivity (94–100%), specificity (63–86%), positive predictive power (78–90%), negative predictive power (83–100%), and convergent validity [19]. 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. Scores for each of the three DSM-IV PTSD clusters were calculated separately by summing scores on the questions corresponding to each cluster. Total PTSD symptom severity ratings can range from zero to eighty.

Procedure

During the cross-sectional study, participants completed two 150-minute sessions in a private room in the laboratory. During the first session, participants segmented the three movies at a coarse grain and completed the recall task for each of these movies. They then completed the Reading Span, Operation Span, Symmetry Span, Shape Comparison, Reading with Distraction, and Synonym and Antonym Vocabulary tasks. During the second session, they segmented the three movies at a fine grain and completed the Selective Reminding, Verbal Paired Associates, World List Recall, Trail Making, Ruff Figural Fluency, Letter Comparison, Pattern Comparison, and the Information Test tasks. After completing the second session, participants were asked whether they were willing to complete the packet of PTSD questionnaires at home. If they agreed, they were given the packet of questionnaires and a pre-addressed and stamped envelope so that they could send the completed questionnaires back to the experimenter.

Results

On the TLEQ, seven participants reported that they had experienced no traumatic life events, six reported one traumatic life event, and 124 reported two or more traumatic life events. PTSD symptom severity scores obtained from the PSDS ranged from 0 to 58. Scores ranged from 0 to 20 for the intrusive recollection cluster, from 0 to 20 for the avoidance and numbing cluster, and from 0 to 17 for the increased arousal cluster. All seven of the participants who stated that they had not experienced any traumatic events had a score of 0 on the PSDS. See **Table 1** for additional descriptive statistics from the TLEQ.

For the event segmentation task, participants varied greatly in the number of segments they identified in the movies. In the coarse segmentation condition, the number of button presses ranged from 1 to 202 (mean = 24.32, sd = 23.74), while in the fine segmentation condition, the number of button presses ranged from 8 to 288 (mean = 61.59, sd = 48.37). However, participants tended to segment a similar number of times across movies: Cronbach's alphas for coarse segmentation and fine segmentation were .89 and .94, respectively (Breakfast Coarse: mean = 27.76, sd = 26.94; Party Coarse: mean = 23.23, sd = 23.81; Gardening

TLEQ Trauma Type	Number of Participants[a]	Index Trauma[b]	Average PTSD Severity[c]	Range PTSD Severity[c]
Natural Disaster	45	1	17	17
Motor Vehicle Accident	35	11	5.91	0–34
Other Accident	18	1	7	7
Military Combat Experience	4	1	6	6
Sudden Death of Loved One	95	36	9.11	0–46
Loved One Survived Injury or Illness	63	6	13.33	0–35
Life Threatening Illness	24	4	17.75	4–39
Robbed	33	3	8	0–14
Badly Injured by Stranger	23	1	2	2
Saw Another Person being Assaulted	24	1	18	18
Threatened Death or Serious Injury	35	6	16	0–40
Physically Punished as Child	28	3	35	5–55
Witnessed Family Violence as Child	45	10	15	0–40
Experienced Intimate Partner Violence	33	4	15.5	0–31
Before 13: Sexual Contact by Someone More than 5 Years Older	26	3	9.67	0–29
Before 13: Sexual Contact with Someone Close to Age	12	0	–	–
Between 13 to 18: Sexual Contact Without Consent	9	1	11	11
After 18: Sexual Contact Without Consent	16	3	4.33	0–11
Sexual Harassment	46	5	3.4	0–8
Experienced Stalking	21	2	22	7–37
Miscarriage	27	0	–	–
Abortion	35	5	5.8	0–14
Other	34	11	26.54	0–58
No Negative Events	3	–	0	0
Listed More than One Index Trauma[d]	10	–	26.2	3–56
Did Not Provide Index Trauma	6	–	6	0–31

Table 1: Descriptive Statistics for TLEQ.
[a] Number of participants who experienced each type of traumatic event at least once.
[b] Index trauma was defined as the event participants indicated caused them the most distress.
[c] Average and Range PTSD severity were calculated using only the PSDS scores of those participants who chose each event as their index trauma.
[d] Participants were instructed to choose the one event that caused them the most distress. However, some participants circled more than one index trauma.

Coarse: mean = 22.19, sd = 18.70; Breakfast Fine: mean = 59.04, sd = 39.24; Party Fine: mean = 67.21, sd = 50.87; Gardening Fine: mean = 58.51, sd = 53.64). The number of meaningful units identified was not significantly correlated with PTSD severity (coarse segmentation: $r = 0.05$, $p = .55$; fine segmentation: $r = 0.02$, $p = .82$).

Preliminary Analyses

To reduce error and loss of degrees of freedom in later analyses, scores on the cognitive tasks were combined into five composite variables: working memory, verbal episodic memory, general knowledge, executive function, and processing speed. See **Table 2** for descriptive statistics for these variables. To create the composite variables, we z-scored the scores for each of the tasks and then averaged the resulting scores. A confirmatory factor analysis found that all of the composite variables except executive function formed latent variables (see [12]). Therefore, the executive function variable was dropped from further analyses.[3]

Gender, age and education were included as covariates in the subsequent analyses. Gender was not correlated with PTSD symptom severity ($r = 0.06$, $p = .24$; males coded as 0, females coded as 1) or with segmentation agreement ($r = -0.04$, $p = .64$). We found significant negative correlations between age and PTSD symptom severity ($r = -0.24$, $p = .004$) and education level and PTSD symptom severity ($r = -0.25$, $p = .003$). However, neither variable

Constructs and Measures	Mean	SD	Skew	Kurtosis
PTSD Symptom Severity[a]	12.88	14.62	1.32	0.97
Working Memory[b]			–0.68	–0.02
Reading Span	21.11	5.78	–1.06	0.83
Operation Span	20.42	6.76	–0.89	–0.33
Symmetry Span	12.56	6.51	0.21	–0.73
Laboratory Episodic Memory[b]			–0.22	–0.44
Selective Reminding	47.07	6.99	–0.29	–0.35
Verbal Paired Associates	18.23	3.94	–0.52	–0.32
Word List Recall	18.51	5.30	–0.45	–0.09
Executive Function[b]			0.16	–0.32
Reading with Distraction	0.46	0.23	1.55	3.93
Trail Making	1.28	0.69	1.02	1.58
Ruff Figural Fluency	75.74	24.27	0.15	–0.26
Processing Speed[b]			0.64	0.19
Shape Comparison	0.99	0.28	0.74	0.84
Letter Comparison	7.20	1.89	0.50	0.29
Pattern Comparison	12.85	2.81	0.49	0.27
General Knowledge[b]			–0.69	–0.32
Information Test	18.86	5.18	–0.75	–0.14
Synonym Vocabulary	0.58	0.29	–0.16	–0.98
Antonym Vocabulary	0.56	0.29	–0.07	–1.10
Event Memory	28.23	11.61	0.31	0.01
Segmentation Agreement	0.60	0.08	–1.02	2.33
Education (years)	15.08	2.47	–0.38	0.21

Table 2: Descriptive Statistics for Tasks and Measures.

[a] PTSD symptom severity was measured using the PSDS.

[b] Because the composite measures were z-scored, the means and standard deviations for these measures are 0 and 1 respectively.

was significantly correlated with segmentation agreement (r = 0.12 and –0.03, respectively).

To determine whether to conduct a standard hierarchical multiple regression analysis, the distributions of the education, PTSD symptom severity, and cognitive composite variables were checked for skew and kurtosis (see **Table 2**). Despite the non-normality of some of the predictors, the residual distributions were normal and homoscedastic, and parametric statistics were therefore used in the following analyses.

Predicting Segmentation Agreement

Participants with greater PTSD symptom severity had lower segmentation agreement scores; the simple correlation between PTSD and segmentation agreement was –0.26 (p = .002; See **Figure 1** for a scatter plot of this relationship). To determine whether this relationship held after controlling for age, education, and general cognitive functioning, these variables were entered into a hierarchical regression analysis. Gender was entered first into the equation, followed by age and education. The four composite variables were then entered into the equation. Together, these variables accounted for 14.8% of the variance in segmentation agreement (p = .002). When PTSD symptom severity was added into the model after these variables, it accounted for an additional 3.8% of the variance in segmentation agreement (p = .02), and in the final model, only PTSD explained unique variance in segmentation agreement, See **Table 3** for a summary of the hierarchical regression analysis that includes age, education, the composite variables and PTSD symptom severity.[4]

Predicting Event Memory

The simple correlation between PTSD and event memory was –0.16 (p = .05; See **Figure 1** for scatter plot of this relationship), and the simple correlation between segmentation agreement and event memory was 0.46 (p < .001). When gender, age, education, and the four composite variables were entered into the model, these variables accounted for 36.3% of the variance in event memory (p < .001).

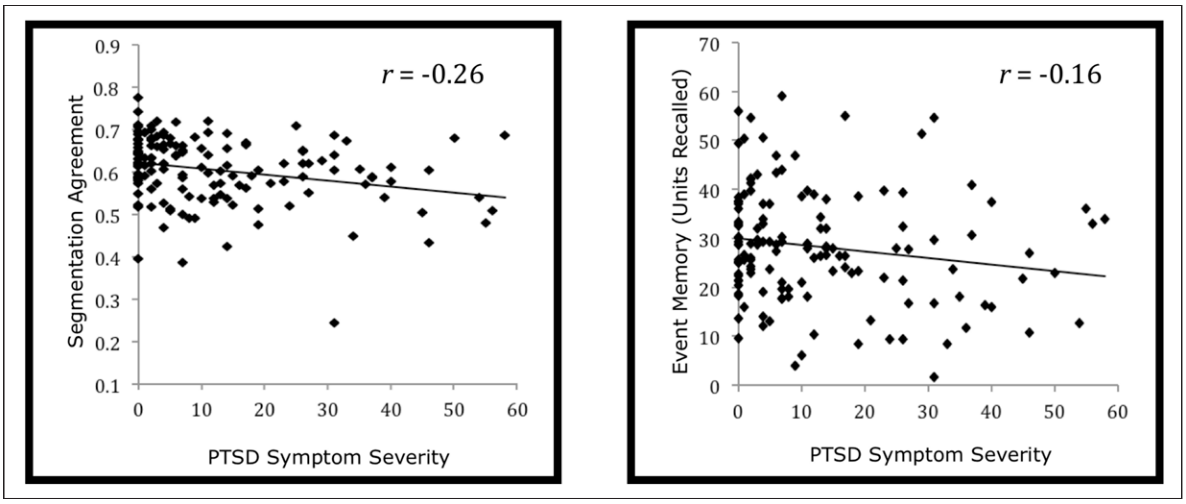

Figure 1: Correlation of PTSD Symptom Severity with segmentation agreement (left) and event memory (right).

PTSD symptom severity did not explain additional unique variance (p = .16). In the final model, only gender and working memory explained unique variance in event memory. See **Table 3** for a summary of the hierarchical multiple regression analysis that includes gender, age, education, the composite variables, and PTSD symptom severity.

Predicting Segmentation Agreement and Event Memory from PTSD Symptom Clusters

The PSDS provides symptom severity scores for each of the three PTSD symptom clusters separately. To test the hypothesis that increased arousal, including hypervigilance, is related to differences in perception of ongoing activity in people with PTSD, the symptom clusters were entered into three additional hierarchical multiple regression analyses. After accounting for the effects of age, education, and the cognitive composite variables, increased arousal accounted for an additional 3.0% (p = .03) of the variance in segmentation agreement and 1.6% (p = .07) of the variance in event memory. Reexperiencing accounted for an additional 3.2% of the variance in segmentation agreement (p = .03) and 0.1% of the variance in event memory (p = .29). Finally, avoidance accounted for an additional 1.7% (p = .10) of the variance in segmentation agreement and 0.1% (p = .17) of the variance in event memory.

Discussion

The association of PTSD symptom severity with less adaptive event segmentation is consistent with findings of negative effects of PTSD on cognition (see [20], for a review). In addition, the finding that increased arousal negatively predicted segmentation agreement supports the hypothesis that this symptom cluster is relevant to the mechanism relating PTSD and the perception of ongoing activity. Of particular note, participants in the current study only viewed neutral movies that were unlikely to be related to their traumatic events, suggesting that the effects pervade everyday cognition.

What mechanism or mechanisms account for the relationship between PTSD and the perception of ongoing activity? One potential cause is a difficulty making accurate predictions. According to Event Segmentation Theory [13], event segmentation results from predictive processes during ongoing perception. As people experience the world, the brain makes predictions about future inputs, and there is evidence that the anterior cingulate cortex (ACC) is important for maintaining these predictions and calculating prediction error [21]. When prediction error spikes, the dopaminergic midbrain is involved in triggering a widespread brain response that includes perceptual orienting and memory updating; this response is experienced as an event boundary [13, 22]. One possibility is that symptoms of PTSD compromise one or more of the steps along the pathway that includes perceptual prediction, error monitoring, orienting, and memory updating.

There is currently little research on the relationship between PTSD and prediction ability. However, neuroimaging studies on PTSD and on mechanisms involved in prediction provide some evidence for the existence of a prediction deficit in PTSD. First, a robust finding in the PTSD functional magnetic resonance imaging (fMRI) literature is that the dorsal ACC is hyperactivated in people with PTSD, even during tasks that are unrelated to participants' traumatic events. This brain area is typically involved in tasks such as performance monitoring, response selection, and error detection [23]. For example, in studies very similar to the ERP studies discussed earlier, Bryant et al. [24] found hyperactivity in the dorsal ACC of people with PTSD in an auditory oddball task that was unrelated to trauma and emotional processing. Felmingham et al. [25] used the same auditory oddball task but also measured skin conductance response to target tones to determine autonomic arousal. They 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 of both of these studies suggest that people with PTSD display increased attention, vigilance, and processing of salient stimuli, consistent with the hyperarousal symptoms of PTSD. Because sensory oddballs are by definition unpredictable and likely to lead to prediction errors, it may be that these studies

	Segmentation Agreement		Event Memory	
Step and Predictor Variable	**B (SE)**	**Δ R²**	**B (SE)**	**Δ R²**
Step 1		0.018		0.166***
Gender	–0.004 (0.014)		4.131 (1.845)*	
Age	0.000 (0.000)		–0.18 (0.053)***	
Education	0.004 (0.003)		1.392 (0.377)***	
Step 2		0.130**		0.236***
Gender	0.001 (0.014)		4.893 (1.688)**	
Age	0.001 (0.001)		–0.009 (0.0646)	
Education	–0.001 (0.003)		0.334 (0.383)	
Working Memory	0.019 (0.010)		3.327 (1.177)**	
Episodic Memory	0.008 (0.009)		2.170 (1.40)	
General Knowledge	0.006 (0.009)		1.27 (1.106)	
Processing Speed	0.010 (0.011)		1.619 (1.286)	
Step 3		0.038*		0.010
Gender	0.001 (0.014)		4.928 (1.680)**	
Age	0.000 (0.001)		–0.033 (0.066)	
Education	–0.002 (0.003)		0.258 (0.384)	
Working Memory	0.018 (0.010)		3.241 (1.173)**	
Episodic Memory	0.007 (0.009)		2.111 (1.135)	
General Knowledge	0.006 (0.009)		1.269 (1.101)	
Processing Speed	0.008 (0.010)		1.461 (1.285)	
PTSD Symptom Severity	–0.001 (0.000)*		–0.086 (0.058)	

Table 3: Hierarchical Regression Predicting Segmentation Agreement and Event Memory.
Note: Standard errors of the regression coefficients are presented in parentheses.
*$p < .05$. **$p < .01$. ***$p < .001$.

reflect hypersensitivity to prediction error amongst those suffering from PTSD.

These previous studies suggest two possible mechanisms that could lead to impaired event segmentation in PTSD. First, chronically elevated prediction error signals could mask transient prediction error spikes, rendering segmentation less reliable. Second, constant vigilance could rob processing resources from the encoding of ongoing activity, resulting in poorer event representations and therefore poorer prediction. In other words, inappropriate monitoring of the environment could function as a secondary task that impairs ongoing event encoding. Interventions directed at these mechanisms may be a promising avenue to address impairments of understanding and memory for everyday activity in PTSD. One possibility would be to train people with PTSD to segment activity more adaptively using feedback, thereby scaffolding the impaired error monitoring mechanisms and reducing the concurrent processing demands.

In a similar way, people with high levels of reexperiencing symptoms may suffer reduced processing availability for encoding the ongoing activity. At event boundaries, when adaptive comprehension already requires greater cognitive effort to reorient and update memory, higher levels of reexperiencing symptoms may reduce available processing capacity and result in the type of disrupted segmentation apparent in the present study.

On the other hand, PTSD symptom severity did not significantly predict performance on the event memory task, though the simple correlation between these measures was only just above the significance cutoff at $p = .05$. As discussed above, previous research suggests that people with PTSD experience memory difficulties (e.g., [15]) and that better performance on the event segmentation task is associated with better memory (e.g., [13]). Given that, in the current study, people with higher PTSD symptom severity displayed greater difficulty with the event segmentation task, it was expected that a similar relationship would hold for event memory. One possibility for the trending, though non-significant, finding in the current study is that the relationship between PTSD symptoms and event memory is strongest in people with clinical levels of PTSD and that a full clinical PTSD sample would be necessary to find a significant relationship between these measures.

It is important to note that the correlational design used here does not establish the directionality of the relationship between PTSD and difficulties with perception and memory of ongoing activity. On one hand, it is possible that PTSD causes deficits in event segmentation: Some people who experience a traumatic event may experience neural changes that alter the way they perceive both their initial traumatic event and later events. One potential mechanism of such an effect is that PTSD-related hyperactivation of the dorsal ACC may lead people with PTSD to be chronically hypervigilant in their search for danger, contributing to an increase in prediction error and therefore to deficits in event segmentation. On the other hand, people who have factors that lead to poorer event segmentation before they experience a traumatic event may be at a higher risk for developing PTSD. Again supposing that ACC hyperactivation produces poorer event segmentation, one possibility is that premorbid ACC dysfunction is a risk factor for PTSD. Recent work by Shin et al. [23] in twin pairs discordant for combat supports this suggestion. The authors found that dorsal ACC hyperactivation is a familial trait that is present even in non-combat exposed co-twins of a PTSD positive twin. 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.

In addition, participants in this study were not given a full clinically administered assessment, and it was therefore not possible to obtain clinical diagnoses for participants. However, the PSDS has high reliability and validity [19]. Furthermore, twenty-eight participants reported PTSD severity scores that were equal to or greater than 26, which is the most conservative cut-off score for clinical PTSD found in the literature [19], suggesting that our pattern of results likely will hold in clinically diagnosed samples. Nonetheless, future research should determine whether these results replicate when participants are diagnosed using a clinician administered assessment and display higher PTSD symptom severity levels.

Participants in this study were not asked whether they were taking medication or receiving therapy. Therefore, it was not possible to determine whether these factors influenced the results of this study. However, it is very unlikely that these factors completely drove the relationship between higher PTSD severity and difficulty on the event segmentation task. First, many people with PTSD symptoms do not seek treatment, whether medication or therapy. In fact, Roberts, Gilman, Breslau, Breslau, & Koenent [26] found that only 53.3% of Whites, 35.3% of Blacks, 42.0% of Hispanics and 32.7% of Asians seek any type of treatment for PTSD. Second, although there are likely fewer participants low in PTSD symptomology who take psychotropic medications or seek therapy for other clinical disorders, a portion of the participants with low PTSD scores likely were taking medication or participating in therapy when they participated in the study. Indeed, the National Comorbidity Survey Replication, which surveyed 9,282 participants representative of the United States population between 2001 and 2003 found a 12-month prevalence rate of psychiatric disorders of 26.2% [27], and found that 17.9% of the total respondents had utilized mental health services during the past year [28]. Therefore, it is unlikely that including medication and therapy seeking rates in the current study would have dramatically changed the patterns of results.

This study did not assess symptoms of clinical disorders other than PTSD. This raises the question of whether the current results are specific to people with higher PTSD symptom severity or whether we would have seen similar patterns of results in people with high levels of other types of psychopathology. Although replications of this study that assess for other psychopathology would be necessary to definitively answer this question, the current study provides some evidence that our results may, at least in part, be specific to people with PTSD. If many other clinical populations display similar deficits on the event segmentation task, we would expect the avoidance symptom cluster in the current study to significantly predict segmentation agreement because many clinical disorders, particularly anxiety disorders, include symptoms of avoidance. This was not the case. The fact that only two of the three symptom clusters predicted performance on the event segmentation task suggests that specific symptoms, not just any symptoms of psychopathology, predict disruptions in comprehension of everyday activity.

Conclusion

In sum, the results of this study suggest that greater PTSD symptomology, and, in particular, higher levels of increased arousal and reexperiencing symptoms, are associated with difficulty adaptively segmenting ongoing neutral activity into meaningful units. The novel finding that people with higher PTSD symptom severity experienced difficulty with event segmentation suggests the possibility for a new intervention for ameliorating some symptoms of PTSD: Training people to segment ongoing activity more adaptively could improve understanding and memory for everyday activity.

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Competing Interests

The authors declare that they have no competing interests.

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Notes

[1] These measures were averaged because there were no a priori hypotheses about potential differences between coarse and fine segmentation agreement.

[2] Recently renamed from the Distressing Event Questionnaire.

[3] When the composite variable for executive function was entered into the hierarchical regression analyses in the same step as the other measures of cognitive function, the patterns of the results did not change and executive function did not explain unique variance in segmentation agreement or event memory.

[4] There was one outlier in the distribution for segmentation agreement. The analyses reported here include this outlier. When this outlier was removed, all of the patterns remained the same.

References

1. Kessler, R. C., Berglund, P., Demler, O., Jin, R., Merikangas, K. R., and 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. DOI: http://dx.doi.org/10.1001/archpsyc.62.6.593
2. American Psychiatric Association. 2000. *Diagnostic and statistical manual of mental disorders* (4th ed., text rev.). Washington, DC: Author.
3. American Psychiatric Association. 2013. Trauma- and Stressor-Related Disorders. In *Diagnostic and statistical manual of mental disorders* (5th ed.). DOI: http://dx.doi.org/10.1176/appi.books.9780890425596.991543
4. Marshall, R. D., Bryant, R. A, Amsel, L., Suh, E. J., Cook, J. M., and Neria, Y. 2007. The psychology of ongoing threat: Relative risk appraisal, the September 11 attacks, and terrorism-related fears. The American Psychologist, 62, 304–316. DOI: http://dx.doi.org/10.1037/0003-066X.62.4.304
5. Beck, A. T., and Emery, G. 1985. Anxiety Disorders and Phobias: A Cognitive Perspective. New York, NY: Basic Books.
6. Polich, J. 2007. Updating P300: an integrative theory of P3a and P3b. Clinical neurophysiology, 118, 2128–2148. DOI: http://dx.doi.org/10.1016/j.clinph.2007.04.019
7. Karl, A., Malta, L. S., and Maercker, A. 2006. Meta-analytic review of event-related potential studies in post-traumatic stress disorder. Biological Psychology, 71, 123–147. DOI: http://dx.doi.org/10.1016/j.biopsycho.2005.03.004
8. Kimble, M., Kaloupek, D., Kaufman, M., and Deldin, P. 2000. Stimulus novelty differentially affects attentional allocation in PTSD. Biological Psychiatry, 47, 880–890. DOI: http://dx.doi.org/10.1016/S0006-3223(99)00258-9
9. Zacks, J. M., Speer, N. K., Swallow, K. M., Braver, T. S., and Reynolds, J. R. 2007. Event perception: A mind-brain perspective. Psychological Bulletin, 133, 273–293. DOI: http://dx.doi.org/10.1037/0033-2909.133.2.273
10. Newtson, D. 1976. Foundations of attribution: The perception of ongoing behavior. In Harvey, J. H., Ickes, W. J., and Kidd, R. F. (Eds.), *New Directions in Attribution Research*. Hillsdale, New Jersey: Lawrence Erlbaum Associates, pp. 223–248.
11. Bailey, H. R., Kurby, C. A., Giovannetti, T., and Zacks, J. M. 2013. Action perception predicts action performance. Neuropsychologia, 51, 1113–1122. DOI: http://dx.doi.org/10.1016/j.neuropsychologia.2013.06.022
12. Sargent, J. Q., Zacks, J. M., Hambrick, D. Z., Zacks, R. T., Kurby, C. A., Bailey, H. R., … , Beck, T. M. 2013. Event segmentation uniquely predicts event memory cognition. Cognition, 120, 241–255. DOI: http://dx.doi.org/10.1016/j.cognition.2013.07.002
13. Zacks, J. M., Speer, N. K., Vettel, J. M., and Jacoby, L. L. 2006. Event understanding and memory in healthy aging and dementia of the Alzheimer type. Psychology and Aging, 21, 466–482. DOI: http://dx.doi.org/10.1037/0882-7974.21.3.466
14. Cassiday, K. L., McNally, R. J., and Zeitlin, S. B. 1992. Cognitive processing of trauma cues in rape victims with post-traumatic stress disorder. Cognitive Therapy and Research, 16, 283–295. DOI: http://dx.doi.org/10.1007/BF01183282
15. Lindem, K., Heeren, T., White, R. F., Proctor, S. P., Krengel, M., Vasterling, J. 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, 105–119. DOI: http://dx.doi.org/10.1023/A:1023394932263
16. Kurby, C. A., and Zacks, J. M. 2011. Age differences in the perception of hierarchical structure in events. Memory & Cognition, 39, 75–91. DOI: http://dx.doi.org/10.3758/s13421-010-0027-2
17. Schwartz, M. F. 1991. The quantitative description of action disorganization after brain damage: A case study. Cognitive Neuropsychology, 8, 381–414. DOI: http://dx.doi.org/10.1080/02643299108253379
18. Kubany, E. S., Haynes, S. N., Leisen, M. B., Owens, J. A., Kaplan, A. S., Watson, S. B., and Burns, K. 2000. Development and preliminary validation of a brief broad-spectrum measure of trauma exposure: The traumatic life events questionnaire. Psychological Assessment, 12, 210–224. DOI: http://dx.doi.org/10.1037/1040-3590.12.2.210
19. Kubany, E. S., Leisen, M. B., Kaplan, A. S., and Kelly, M. P. 2000. Validation of a brief measure of posttraumatic stress disorder: The distressing events questionnaire (DEQ). Psychological Assessment, 12, 197–209. DOI: http://dx.doi.org/10.1037/1040-3590.12.2.197
20. Buckley, T., Blanchard, E., and Neill, W. 2000. Information Processing and PTSD: A Review of the Empirical Literature. Clinical Psychology Review, 28, 1041–1065. DOI: http://dx.doi.org/10.1016/S0272-7358(99)00030-6
21. Cohen, J. D., Botvinick, M., and Carter, C. S. 2000. Anterior cingulate and prefrontal cortex: Who's in

control? Nature Neuroscience, 3, 421–423. DOI: http://dx.doi.org/10.1038/74783
22. Sokolov, E. N., Spinks, J. A., Naeaetaenen, R., and Lyytinen, H. (Eds.). 2002. The orienting response in information processing. Mahwah, NJ: Erlbaum.
23. Shin, L. M., Lasko, N. B., Macklin, M. L., 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, 1099–1107. DOI: http://dx.doi.org/10.1001/archgenpsychiatry.2009.138
24. 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. DOI: http://dx.doi.org/10.1016/j.biopsych.2005.03.021
25. Felmingham, K. L., Williams, L. M., Kemp, A. H., Rennie, C., Gordan, E., and 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. DOI: http://dx.doi.org/10.1016/j.pscychresns.2008.12.005
26. Roberts, A. L., Gilman, S. E., Breslau, J., Breslau, N., and Koenen, K. C. 2011. Race/ethnic differences in exposure to traumatic events, development of post-traumatic stress disorder, and treatment- seeking for post-traumatic stress disorder in the United States. Psychological Medicine, 41(1), 71–83. DOI: http://dx.doi.org/10.1017/S0033291710000401.Race/ethnic
27. Kessler, R. C., Chiu, W. T., Demler, O., and Walters, E. E. 2005. Prevalence, severity, and comorbidity of 12-month DSM-IV disorders in the National Comorbidity Survey Replication. Archives of General Psychiatry, 62, 617–627. DOI: http://dx.doi.org/10.1001/archpsyc.62.6.617
28. Wang, P. S., Lane, M., Olfson, M., Pincus, H. A., Wells, K. B., and Kessler, R. C. 2016. Twelve-Month Use of Mental Health Services in the United States. Archives of General Psychiatry, 62, 629–640. DOI: http://dx.doi.org/10.1001/archpsyc.62.6.629

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