Event-based prospective memory among veterans: The role of posttraumatic stress disorder symptom severity in executing intentions

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ABSTRACT

Objective: Posttraumatic stress disorder (PTSD) has been linked with neuropsychological deficits in several areas, including attention, learning and memory, and cognitive inhibition. Although memory dysfunction is among the most commonly documented deficits associated with PTSD, our existing knowledge pertains only to retrospective memory. The current study investigated the relationship between PTSD symptom severity and event-based prospective memory (PM).

Method: Forty veterans completed a computerized event-based PM task, a self-report measure of PTSD, and measures of retrospective memory.

Results: Hierarchical regression analysis results revealed that PTSD symptom severity accounted for 16% of the variance in PM performance, \( F(3, 36) = 3.47, p < .05 \), after controlling for age and retrospective memory. Additionally, each of the three PTSD symptom clusters was related, to varying degrees, with PM performance.

Conclusions: Results suggest that elevated PTSD symptoms may be associated with more difficulties completing tasks requiring PM. Further examination of PM in PTSD is warranted, especially in regard to its impact on everyday functioning.

Associations between posttraumatic stress disorder (PTSD) and deficits on performance-based neuropsychological tasks have been well documented and commonly include difficulty learning and recalling new information (Brewin, 2011; Schuitevoerder et al., 2013), attentional deficits (Jenkins, Langlais, Delis, & Cohen, 2000), impaired cognitive inhibition (Shucard, McCabe, & Szymanski, 2008; Swick, Honzel, Larsen, Ashley, & Justus, 2012), and working memory deficits (Leskin & White, 2007; Vasterling, Brailey, Constans, & Sutker, 1998). The results of a recent meta-analysis support these findings, further indicating that the largest effect sizes pertained to new verbal learning and processing speed (Scott et al., 2015). Such deficits are thought to reflect underlying neural abnormalities associated with PTSD, including dysfunction within limbic and paralimbic circuits involving the prefrontal cortex, hippocampus, and amygdala (Rauch, Shin, & Phelps, 2006). In addition to their mechanistic significance, neurocognitive deficits may contribute to the functional impairments that commonly accompany PTSD (Hoge, Terhakopian, Castro, Messer, & Engel, 2007; Rodriguez, Holowka, & Marx, 2012) and adversely affect quality of life (Schnurr, Lunney, Bovin, & Marx, 2009).

Memory dysfunction holds particular significance to PTSD, as it ranks high among the cognitive domains commonly impaired in PTSD and has relevance to neuroanatomical models of PTSD implicating the hippocampus and prefrontal cortex as well as to day-to-day functioning (Geuze, Vermetten, de Kloet, Hijman, & Westenberg, 2009). Most studies of memory performance in PTSD (e.g., Gilbertson, Gurvits, Lasko, Orr, & Pitman, 2001; Jelinek et al., 2006; Vasterling et al., 2002) have used routine clinical
neuropsychological episodic memory tasks. These tasks target “retrospective memory,” or the ability to explicitly recall information or events that were previously learned or experienced. Less is known about the association between PTSD and prospective memory (PM), or the ability to remember to complete a plan of action in the future. Examples of activities that require PM include remembering to pick a child up from school, attend a meeting, or take medication. Several studies have revealed a relationship between PM measures and day-to-day functioning, including medication adherence (Vedhara et al., 2004) and activities of daily living (Smits, Deeg, & Jonker, 1997). The purpose of this study was to extend our understanding of memory deficits associated with PTSD by examining the extent to which PTSD symptom severity is related to PM, a functionally relevant domain not previously examined in the PTSD literature.

There are a number of reasons to hypothesize that PTSD would be associated with impaired PM. First, neuroanatomical models of PTSD (e.g., Rauch et al., 2006) implicate the hippocampus and medial prefrontal cortex, areas thought to be involved in PM (Adda, Castro, Além-Mar e Silva, de Manreza, & Khashayar, 2008; Burgess, Gonenc-Yaacov, & Volle, 2011; Burgess, Quayle, & Frith, 2001). Relatedly, PTSD is associated with deficits in retrospective memory (Johnsen & Asbjørnsen, 2008) and inhibitory processing (Shucard et al., 2008; Swick et al., 2012), both of which are thought to be critical for successful PM (Glisky, 1996; Martin, Kliegel, & McDaniel, 2003; Schnitzspahn, Stahl, Zeintl, Kaller, & Kliegel, 2013) and stem from decreased activity in the hippocampus and inferior lateral prefrontal cortex (Rauch et al., 2006), respectively. Finally, studies have also revealed an association between PM deficits and anxiety states (Harris & Cumming, 2003; Harris & Menzies, 1999), behaviors (Cuttler & Graf, 2007, 2008, 2009), and disorders, specifically obsessive compulsive disorder (Marsh et al., 2009; Racsmány, Demeter, Csigó, Harsányi, & Németh, 2011; although see Harris, Vaccaro, Jones, & Boots, 2010, for contradictory findings). Thus, it is conceivable that PM is impaired in other disorders with prominent anxiety features, such as PTSD.

In this first study examining the relationship between PM and PTSD, we hypothesized that PTSD symptom severity, as indicated by scores on a self-report measure of PTSD symptomatology, would be inversely related to PM performance. More specifically, we predicted that the Diagnostic and Statistical Manual of Mental Disorders, Fourth Edition (DSM–IV; American Psychiatric Association, 1994) PTSD symptom severity would be inversely correlated with performance on a PM task after adjusting for both age and retrospective memory performance. Because prior research has indicated that PTSD symptom clusters may be differentially correlated with neuropsychological performance (Swick et al., 2012; Vasterling et al., 1998), we also explored the extent to which specific DSM–IV PTSD symptom clusters (i.e., reexperiencing, avoidance/numbing, arousal) were associated with PM performance. Finally, because a growing body of research has linked depressive symptoms, which are frequently comorbid with PTSD (Campbell et al., 2007), to impaired PM performance (Li, Loft, Weinborn, & Maybery, 2014; Rude, Hertel, Jarrold, Covich, & Hedlund, 1999), we investigated the relationship between depressive symptoms and PM.

**Method**

**Participants**

Forty military veterans were recruited from PTSD-related participant recruitment databases (i.e., veterans who participated in previous studies giving their permission to be recontacted for future research) at the Veterans Affairs Boston Healthcare system. These databases were developed for a range of military trauma studies in which PTSD was a variable of interest, including studies incorporating healthy non-PTSD comparison groups. Veterans were excluded from participating if they (a) endorsed a history of head trauma with an associated loss of consciousness of greater than 15 min, (b) endorsed central nervous system disease, or (c) were taking neuroleptic medications. Additionally, volunteers were excluded from participating if they met criteria for current (defined as past three months) alcohol or substance abuse or dependence or lifetime psychotic or bipolar disorder as assessed via an abbreviated Structured Clinical Interview for DSM–IV Axis I Disorders (SCID; First, Spitzer, Gibbon, & Williams, 2002). Finally, participants were excluded if they endorsed a history of attention deficit hyperactivity disorder or learning disability in response to screening questions. One hundred and fifty veterans were initially contacted and screened by phone. Of those 150
veterans, 89 were excluded for screening positive for a current alcohol use disorder on the Alcohol Use Disorders Identification Test, seizure disorder, attention-deficit/hyperactivity disorder (ADHD), learning disability, history of traumatic brain injury, or history of psychiatric disorder. All veterans that met study criteria and agreed to participate provided written informed consent and were compensated for participating in the experiment. All data reported were collected in compliance with the Helsinki Declaration and with the approval of the Department of Veterans Affairs Internal Review Board.

**PTSD symptoms**

PTSD symptom severity was assessed using the PTSD Checklist, Civilian Version (PCL-C; Weathers, Litz, Herman, Huska, & Keane, 1993). The PCL-C is a 17-item self-report scale that assesses DSM-IV symptom criteria over a period of 1 month. The response set for each item ranges from 1 (“not at all”) to 5 (“extremely”), yielding a potential summary score range of 17–85, with higher scores indicating greater PTSD symptom severity. The PCL has demonstrated acceptable levels of discriminant validity compared with other measures of psychopathology (Blanchard, Jones-Alexander, Buckley, & Forneris, 1996) and is highly correlated with the Clinician-Administered PTSD Scale (Blake et al., 1995). As described below, in our primary analyses, we examined PTSD as a dimensional, rather than categorical, variable as a reflection of our interest in the continuous nature of the construct and relatedly to test our hypotheses that PM would show a linear relation to PTSD within the entire continuum of symptom severity. To provide further clinical characterization of the sample we also used a BDI-II cut-score of 20 (Li et al., 2014) to identify those participants that endorsed either moderate or severe depressive symptoms. As an estimate of native intellectual potential we administered the Wechsler Test of Adult Reading (WTAR; Wechsler, 2001). Retrospective declarative memory was assessed using the 16-item California Verbal Learning Test–II (CVLT-II; Delis, Kramer, Kaplan, & Ober, 2000) Long Delay Free Recall trial. As an additional index of retrospective memory, following the completion of the PM task, participants were asked to describe the tasks involved in the study.

**Depression symptoms, intellectual potential, and retrospective memory**

We administered the Beck Depression Inventory–II (BDI–II; Beck, Steer, & Brown, 1996) to assess depression symptom severity. As with PTSD, we also examined depression as a dimensional variable. However, to provide additional clinical characterization of the sample we also used a BDI–II cut-score of 20 (Li et al., 2014) to identify those participants that endorsed either moderate or severe depressive symptoms. As an estimate of native intellectual potential we administered the Wechsler Test of Adult Reading (WTAR; Wechsler, 2001). Retrospective declarative memory was assessed using the 16-item California Verbal Learning Test–II (CVLT–II; Delis, Kramer, Kaplan, & Ober, 2000) Long Delay Free Recall trial. As an additional index of retrospective memory, following the completion of the PM task, participants were asked to describe the tasks involved in the study.

**Procedure**

The experimental session lasted approximately 90 min. After providing written informed consent and completing an abbreviated SCID, participants completed the computer-based PM task. Participants then completed the WTAR and the CVLT–II, followed by the self-report questionnaires. Finally, participants were debriefed and provided time to ask questions.

**PM paradigm**

PM paradigms are designed to simulate routine everyday tasks in which individuals are typically involved in one or more ongoing tasks throughout the course of a day that must be interrupted at the appropriate time to initiate a prospectively remembered activity (e.g., remembering to take a medication on schedule while performing routine work tasks). In everyday life, the task to be remembered may optimally occur in response to a specific event (e.g., passing the grocery store on the way home) or within a specific timeframe (e.g., taking a medication in the evening). The PM paradigm in this study was a classic laboratory event-based task (vs. time-based) in that participants were engaged in an ongoing distractor task requiring periodic interruption in response to cues (i.e., “events”) to successfully complete a specified PM, or “target,” task (for similar paradigms see Altgassen, Henry, Bürgler, & Kliegel, 2011; Loft et al., 2014). This task has been shown to be a reliable measure of PM (Kelemen, Weinberg, Alford, Mulvey, & Kaeochinda, 2006). Specifically, participants were given a sheet of paper detailing task instructions and were asked to
read it carefully. The instructions indicated that they would be asked to complete a multiple-choice test of general knowledge and trivia (i.e., the ongoing task) and that they would have a total of 12 seconds to respond to each question. Participants were also informed that, during the trivia task, they should press the “6” key in response to any trivia questions that contained the word “president” (i.e., the secondary PM task). The instructions for the PM task were then presented on the computer monitor. Participants were then asked to write that exact instruction on a sheet of paper and to repeat the instructions aloud to ensure that they each understood what they were to do in the experiment. Participants were next told that the experiment would begin, and no further mention of the PM task was made. Participants did not receive feedback regarding PM task performance during the experiment.

The multiple-choice trivia questions with the embedded PM task proceeded for approximately 42 minutes, after which participants were asked to describe the tasks involved (i.e., answering multiple-choice questions; pressing the “6” key when seeing the word “president”). The trivia questions consisted of 196 questions selected from a previous study (McDaniel, Glisky, Rubin, Guynn, & Routhieaux, 1999) and were presented on a Gateway E-6610D PC, using DMDX (Forster & Forster, 2003). Questions were presented in random order in Times New Roman 12-point font in the center of the monitor. Beneath each question, four response options corresponding to multiple-choice answers were presented and labeled “A,” “B,” “C,” or “D.” Successive questions appeared at 12-second intervals, regardless of how quickly the participant responded to the question. The duration of the interval between making a response and the presentation of the next question therefore varied depending on the response time.

Performance on the eight target PM trials, indicated by the total number of correct responses, comprised the primary dependent variable. Correct PM responses were defined as pressing the “6” key in response to questions that contained the word “president,” either during the presentation of the target question or immediately following its presentation, but prior to the presentation of a subsequent question. All “6” key presses made in response to “president” and prior to the appearance of subsequent questions were given a value of 1. A value of 0 was given for any omissions or key presses made after the presentation of subsequent questions.

Additional variables of interest included measures of ongoing task performance: the number of trivia questions answered correctly and the average response time to answer each question. Performance differences on these measures could reflect differences in engagement with the ongoing task and subsequently contribute to PM performance differences. Therefore, we measured ongoing task performance to determine whether any PM performance deficits were explainable on the basis of task engagement.

**Data analysis**

All independent and dependent variables were normally distributed, with skewness ranging from −0.75 to 0.55, and kurtosis ranging from −1.4 to −0.1. To test our primary hypothesis, that PTSD symptom severity would be inversely related to PM performance, we conducted a hierarchical regression analysis. Age was the first variable entered, followed by CVLT–II Long Delay Free Recall. This order was based on previous work showing that both age and retrospective memory can affect PM performance (McDaniel & Einstein, 2011). The PCL-C summary score was entered next to identify any unique variance contributed by PTSD symptom severity to PM performance over and above that explained by age and retrospective memory. For ease of interpretation, age and CVLT–II Long Delay Free Recall were centered at the sample mean; the PCL-C was centered at 50 and divided by 10 such that the resulting regression coefficients would reflect the associated change in PM performance for every 10-point difference in PCL-C scores, an increment reflecting a clinically significant increase in PTSD symptomatology.

We considered including BDI–II scores in the model to examine the association of PTSD with PM, independent of depressive symptoms, given the high comorbidity of depression with PTSD; however, examination of multicollinearity indicated that the variance inflation factor (VIF) for BDI scores was unacceptably high (>2.5) when included in the same model as the PCL-C, which could lead to unstable regression coefficients. Thus, we examined associations between depressive symptoms and PM performance in a second, post hoc model that was identical to the first
regression model with respect to the variables of interest and the order of entry, except that BDI–II summary scores were substituted for PCL-C summary scores in the third step. The post hoc model allowed us to compare the magnitude of the association between depression and PM and that between PTSD and PM.

Partial correlational analyses controlling for age and retrospective memory were conducted to explore potential relations between PCL-C symptom cluster scores and PM performance. Finally, Pearson product–moment correlations were conducted to identify significant associations between indicators of task engagement (i.e., number of trivia questions answered correctly and reaction times to trivia questions) and PTSD symptom severity.

### Results

#### Participant characteristics

The majority of participants were White (70%) and male (88%), with a mean age of 39.6 years ($SD = 10.2$ years; range = 24–60 years). Veterans had completed an average of 13.9 years of education ($SD = 2.1$ years) and obtained a mean WTAR score of 38.3 ($SD = 7.2$), suggesting that as a group, participants were of average intelligence. Mean PCL-C and BDI–II scores were 45.9 ($SD = 17.0$), and 16.0 ($SD = 12.3$), respectively, indicating a broad range of both PTSD and depression severity levels and that the sample on average reported moderate PTSD and mild depression symptoms.

With regard to retrospective memory, the overall sample performed in the average range and recalled a mean of 12.2 of 16 potential items on the CVLT–II Long Delay Free Recall ($SD = 2.8$). Table 1 provides additional information related to self-report measure data and task performance.

#### Prospective memory performance

Tests of multicollinearity for each regression analysis indicated that (a) all VIFs ranged from 1.0 to 1.3, suggesting that the predictor variables in each model were not collinear with one another; and (b) Durbin–Watson statistics for both models were also acceptable (2.0 to 2.2), indicating that the assumption of independent errors was met.

As depicted in Table 2, the primary regression analysis examining the association between PTSD symptom severity and PM revealed that age accounted for 5% of the variance in PM performance, with CVLT–II Long Delay Free Recall contributing an additional 1% ($ps > .10$). PTSD symptom severity, as indicated by PCL-C scores, accounted for an additional 16% of the variance in PM performance. As hypothesized, more severe PTSD symptoms were associated with poorer PM performance. The beta coefficient for PCL-C ($B = –0.71$) indicates that every 10 additional points on the PCL-C was associated with a PM performance decrement of 0.71. Overall, the model accounted for 22% of the variance in PM performance, $F(3, 36) = 3.47, p < .05$. These findings held when the above regression was repeated with PTSD symptoms.

### Table 1. Demographic information, self-report, and task performance.

<table>
<thead>
<tr>
<th>Variable</th>
<th>$M (SD)$</th>
<th>Range</th>
<th>$n$ (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (years)</td>
<td>39.6 (10.2)</td>
<td>24–60</td>
<td></td>
</tr>
<tr>
<td>Education (years)</td>
<td>13.9 (2.1)</td>
<td>11–19</td>
<td></td>
</tr>
<tr>
<td>Women</td>
<td>5 (12.5)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ethnic minority</td>
<td>5 (12.5)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Estimated IQ (WTAR)</td>
<td>107.2 (11.0)</td>
<td>79–125</td>
<td></td>
</tr>
<tr>
<td>PCL-C summary score</td>
<td>45.9 (17.0)</td>
<td>17–84</td>
<td></td>
</tr>
<tr>
<td>PTSD screen positive</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>BDI–II summary score</td>
<td>16.0 (12.3)</td>
<td>0–46</td>
<td></td>
</tr>
<tr>
<td>Depression screen positive</td>
<td>14 (35)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CVLT–II</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Trial 1</td>
<td>7.2 (2.8)</td>
<td>2–14</td>
<td></td>
</tr>
<tr>
<td>Trials 1–5</td>
<td>55.4 (12.1)</td>
<td>29–75</td>
<td></td>
</tr>
<tr>
<td>Long Delay Free Recall</td>
<td>12.2 (2.8)</td>
<td>6–16</td>
<td></td>
</tr>
<tr>
<td>PM accuracy (out of 8)</td>
<td>4.2 (2.8)</td>
<td>0–8</td>
<td></td>
</tr>
<tr>
<td>Ongoing task performance</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hit rate</td>
<td>.37 (.07)</td>
<td>24–54</td>
<td></td>
</tr>
<tr>
<td>Reaction time (ms)</td>
<td>2417.42 (907.14)</td>
<td>1059.52–5270.45</td>
<td></td>
</tr>
</tbody>
</table>

Table 2. Multiple regression analysis with age, retrospective memory, and PCL-C as predictors of PM performance.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Step 1</th>
<th>Step 2</th>
<th>Step 3</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>B</td>
<td>SE B</td>
<td>β</td>
</tr>
<tr>
<td>Constant</td>
<td>4.17</td>
<td>0.45</td>
<td>.21</td>
</tr>
<tr>
<td>Age</td>
<td>-0.06</td>
<td>0.04</td>
<td></td>
</tr>
<tr>
<td>CVLT–II LDF</td>
<td>.13</td>
<td>.18</td>
<td>.13</td>
</tr>
<tr>
<td>PCL-C</td>
<td>-0.71</td>
<td>.25</td>
<td>- .43**</td>
</tr>
</tbody>
</table>

Note. Age and retrospective memory were centered at the sample mean, and PCL-C was centered at 50 and divided by 10. PM = prospective memory; CVLT–II LDF = California Verbal Learning Test–Second Edition, Long Delay Free Recall; PTSD = posttraumatic stress disorder; PCL-C = PTSD Checklist, Civilian. \( R^2 = .05 \) for Step 1; \( \Delta R^2 = .01 \) for Step 2; \( \Delta R^2 = .17 \) for Step 3.

Table 3. Partial correlation between PCL-C clusters, BDI–II, and PM performance controlling for age and retrospective memory.

<table>
<thead>
<tr>
<th>Variable</th>
<th>PCL B</th>
<th>PCL C</th>
<th>PCL D</th>
<th>BDI–II</th>
</tr>
</thead>
<tbody>
<tr>
<td>PM</td>
<td>- .31*</td>
<td>- .43**</td>
<td>- .41*</td>
<td>- .33*</td>
</tr>
<tr>
<td>PCL B</td>
<td>—</td>
<td>.73***</td>
<td>.75***</td>
<td>.60***</td>
</tr>
<tr>
<td>PCL C</td>
<td>—</td>
<td>.90***</td>
<td>.75***</td>
<td>—</td>
</tr>
<tr>
<td>PCL D</td>
<td>—</td>
<td></td>
<td>.75***</td>
<td>—</td>
</tr>
<tr>
<td>BDI–II</td>
<td></td>
<td></td>
<td></td>
<td>—</td>
</tr>
</tbody>
</table>

Note. PM = prospective memory; PTSD = posttraumatic stress disorder; PCL-C = PTSD Checklist, Civilian; PCL B = PCL-C Cluster B (reexperiencing); PCL C = PCL-C Cluster C (avoidance/numbing); PCL D = PCL-C Cluster D (hyperarousal); BDI-II, Beck Depression Inventory–II.

* \( p < .05 \); ** \( p < .01 \); *** \( p < .001 \). **p ≤ .01.

entered as a dichotomous variable with a cut-score of 50, \( F(3, 36) = 2.72; p = .05 \). Additional analyses were conducted to determine whether native intellectual potential (WTAR), education, basic attention (CVLT–II Trial 1), or learning (CVLT–II total) accounted for greater variance than retrospective memory and altered the relation between PTSD and PM. We substituted those variables, independently, for CVLT–II Long Delay Free Recall in the primary regression. The results were unchanged and revealed that native intellectual potential, education, attention, and learning each accounted for non-significant portions of variance in PM performance and had no impact on the relation between PTSD and PM.

The results of a second, post hoc regression, in which BDI–II scores were substituted for PCL-C scores, revealed that the inclusion of depressive symptoms accounted for an additional 10% of the variance in PM performance \( (\beta = -.35, p < .05) \) over and above that accounted for by age and CVLT–II Long Delay Free Recall; the overall model approached but did not reach statistical significance, \( F(3, 36) = 2.34, p = .09 \).

Partial correlations, depicted in Table 3, revealed that the three PTSD symptom clusters were each related, to varying degrees, to PM performance. Specifically, Clusters C (avoidance and numbing symptoms) and D (hyperarousal symptoms) were each negatively correlated with PM performance, such that higher levels of both avoidance and arousal symptoms were associated with less proficient PM performance \( (r = -.43, p < .01; r = -.41, p = .01, \text{respectively}) \). Though not statistically significant, the partial correlation between Cluster B (reexperiencing symptoms) scores and PM performance \( (r = -.31, p = .06) \) suggests a trend for more severe reexperiencing symptoms to be associated with less proficient PM performance. The results of a Fisher’s \( t \)-to-\( z \) transformation confirmed that the correlations between PM performance and each of the three symptom clusters were not significantly different \( (p > .28) \).

Ongoing task performance

Correlational analyses revealed no significant association between PCL-C scores and the number of trivia questions answered correctly \( (r = .13, p > .05) \). Similarly, PCL-C summary scores did not correlate significantly with reaction times when answering trivia questions \( (r = -.04, p > .9) \). These results suggest that participants did not differ in their level of engagement as a function of symptom severity.

Retrospective memory

All participants successfully recalled the specifics of the task, including that they were to answer trivia questions and to press the “6” key whenever the word “president” appeared. These results, in addition to the failure (reported previously) to detect a significant relation between CVLT–II Long Delay Free Recall and PM performance, suggest that retrospective memory impairment cannot explain the association between PTSD symptoms and PM performance.
Discussion

This study examined the relation between PTSD symptom severity and PM in a sample of military veterans. Although PTSD has been associated with a variety of neuropsychological abnormalities, including attentional deficits (Jenkins et al., 2000), diminished cognitive inhibition (Shucard et al., 2008; Swick et al., 2012), and working memory deficits (Leskin & White, 2007; Vasterling et al., 1998), this is, to our knowledge, the first study to have investigated the possible association between PTSD and PM. As hypothesized, the results revealed a negative correlation between PTSD symptom severity and PM performance on an event-based PM task. Specifically, veterans with greater PTSD symptom severity completed significantly fewer PM actions (i.e., pressed the “6” key in response to seeing “president”) than did veterans with less severe PTSD symptoms. Our findings suggest that overall PTSD symptom severity was associated with PM deficits and that no single component accounted for this relationship. Although the strength of correlation of each of the three DSM–IV PTSD symptom clusters (i.e., reexperiencing, avoidance/numbing, hyperarousal) with PM performance varied to some degree, all three symptom clusters appeared to contribute to PM performance deficits.

We considered several factors that may account for these results. First, retrospective memory performance has been shown to contribute to PM deficits (McDaniel & Einstein, 2011) and has been found to be less proficient in PTSD (Brewin, 2011; Schuitevoerder et al., 2013). In the current study, retrospective memory was not significantly associated with PM, suggesting that PTSD is associated with poorer PM performance, independent of retrospective memory. We also considered learning, given meta-analytic findings of impaired learning in the context of PTSD (Scott et al., 2015). However, the pattern of results remained unchanged when we substituted learning performance for delayed recall in the primary regression, suggesting that differences in learning ability did not account for the relation between PTSD and PM. The failure to detect a statistically significant relationship between PM and retrospective memory and between PM and learning in this study is not surprising given the minimal demands placed on retrospective memory and learning (i.e., there was only a single association that needed to be learned and maintained) and by the finding that, as compared with normative data, no participants performed in the impaired range on a measure of delayed memory (CVLT–II Delayed Free Recall). The finding that each participant successfully recalled the cue–intention association after completing the study further suggests that the poor PM performance in this study was not driven by retrospective memory performance or the learning upon which it depends.

Additional cognitive processes that are often impaired in PTSD and that may relate to the present findings include attention, working memory, and inhibition. Although attentional processes may contribute to the relation between PTSD and PM, basic attention, as indicated by performance on CVLT–II Trial 1, was not significantly related to PM performance in the current study. Reduced inhibition abilities could have contributed to difficulty monitoring the environment for a PM cue, thus reducing the likelihood of successful PM execution. However, this explanation is less likely in the current study, due to the use of a focal cue. That is, successful completion of the ongoing task in this study (i.e., answering trivia questions) required “focal” processing of individual words, including the PM cue (“president”). Nonfocal cues, in contrast, are cues that are not necessarily processed in the completion of the ongoing task (e.g., the syllable “tor”) and are therefore typically more difficult to detect. Inhibition is another factor that could have contributed to the relation between PTSD and PM. Reduced inhibition abilities could have contributed to difficulty disengaging from the ongoing trivia task to perform the PM task. Because we did not examine working memory or inhibition in the current study, these are possibilities that will need to be investigated in future studies.

We also considered alternate explanations nonspecific to PTSD. First, there was no significant relationship between ongoing task performance and PM performance, suggesting that PM performance differences across PTSD symptom levels were not a product of lower task engagement in participants with more severe PTSD. Second, we examined the relationship between depressive symptoms, which frequently co-occur with PTSD
symptoms (Campbell et al., 2007) and have been shown to be associated with PM performance deficits under some conditions. Findings indicated that depression symptom severity was negatively correlated with PM performance, though to a lesser degree than were PTSD symptoms. However, the high degree of collinearity between PTSD and depression symptoms limited our ability to further investigate the relationship between depression and PM. To better understand the independent contributions of PTSD and depression symptoms on PM, we will need to replicate these findings in a larger sample.

The current results are consistent with a developing picture of PM deficits in the context of anxiety states and behaviors (Cuttler & Graf, 2007, 2008, 2009; Harris & Cumming, 2003) and depressive symptomatology (Li et al., 2014; Rude et al., 1999), independent of retrospective memory. The relatively limited findings in these areas suggest that increasing levels of anxiety and depressive symptoms are related to poorer PM performance, consistent with the current pattern of results. Therefore, the results of this study contribute to our relatively nascent appreciation of the associations of mood and anxiety with PM and build upon our understanding of the psychological and functional correlates of PTSD.

A wide range of daily tasks depend upon PM (e.g., remembering to take one’s medication and completing job-related activities). Recent research has shown that PTSD is related to functional impairment in the areas of social, interpersonal, and occupational functioning, among others (Hoge et al., 2007; Rodriguez et al., 2012). It may be that diminished PM contributes to the functional impairment associated with PTSD. Similarly, PM difficulties experienced by patients with PTSD may contribute to difficulties fully adhering to certain aspects of both psychopharmacological (e.g., forgetting to take medications on schedule) and psychosocial (e.g., forgetting to initiate homework assignments) interventions. Therefore, better understanding of the relations among PTSD symptoms, PM, and functional impairment could inform efforts to improve the level of functioning and overall quality of life of many veterans.

Limitations of the current study include reliance upon the PCL-C as an indicator of PTSD severity. However, there is strong agreement between the PCL and the Clinician-Administered PTSD Scale (CAPS; Blanchard et al., 1996), the “gold standard” for diagnosing PTSD. The relatively small sample size necessitates replication with larger samples. The lack of demographic diversity among participants may also limit the generalizability of findings. Additionally, although we used a classic laboratory-based PM task to determine whether a relationship exists between PTSD and PM, future studies would benefit from inclusion of complementary ecological measures of PM.

Finally, we limited assessment of key potential cognitive mechanisms subserving PM to retrospective memory performance and measured only event-based PM. Based on previous research, it is possible that the PM deficit observed in the current study was driven by deficits in working memory and or inhibition (Rose, Rendell, McDaniel, Aberle, & Kliegel, 2010; Schnitzspahn et al., 2013), which might have resulted in difficulty maintaining the PM intention or disengaging from the ongoing task to initiate the intention (Kliegel, Martin, McDaniel, & Einstein, 2002). Examination of the relationship of PTSD to PM on PM tasks placing greater demands on executive functioning, including event-based tasks that incorporate nonfocal cues or time-based tasks of PM, may also be informative. It could be hypothesized, for example, that individuals with PTSD will have even greater difficulty on such PM tasks, as nonfocal cues and time-based tasks require more self-initiated processing than the relatively simple focal event-based task employed in the current study. For example, individuals with PTSD may have considerable difficulty engaging in the strategic monitoring of the environment and time that often predicts PM performance.

Limitations notwithstanding, the results of the current study provide the first evidence of an association between PTSD symptomatology and PM, adding a unique element to our understanding of the neurocognitive profile of PTSD. Given the significance of PM to functioning (Kliegel, Jager, Altgassen, & Shum, 2008; Woods et al., 2008) combined with the significant functional impairment in PTSD, future work would benefit from examination of relations among PTSD, PM, and functional impairment. Progress in these realms could lead to the development of effective PM interventions tailored to the unique needs of patients with PTSD.
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