Cognitive, Affective, & Behavioral Neuroscience (2023) 23:1428–1444
https://doi.org/10.3758/s13415-023-01121-4

RESEARCH ARTICLE

Imagining emotional future events in PTSD: clinical and neurocognitive correlates

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Accepted: 10 July 2023 / Published online: 12 September 2023

Abstract
Emotional future thinking serves important functions related to goal pursuit and emotion regulation but has been scantly studied in posttraumatic stress disorder (PTSD). The current study sought to characterize emotional future thinking in PTSD and to identify clinical and neurocognitive profiles associated with potential alterations in the level of detail in narratives of imagined future events. Fifty-eight, trauma-exposed, war-zone veterans, who were classified into current PTSD, past PTSD, and no-PTSD groups, were asked to vividly imagine future events in response to positive and negative cue words occurring in the near and distant future. These narratives were scored for internal (i.e., pertaining to the main event) and external (i.e., tangential to the main event) details. Participants also performed neurocognitive tasks of generative ability, working memory, and relational verbal memory. Linear mixed modeling revealed that the current and past PTSD groups generated fewer internal details than the no-PTSD group across positive and negative cue words and across temporal proximity. Partial least squares analysis revealed that symptom severity for all PTSD clusters was inversely associated with production of internal details, albeit with the association relatively weaker for intrusion symptoms. Among the neurocognitive tasks, only relational verbal memory was associated with production of internal details. These findings suggest, as predicted, that functional avoidance may underlie reduced detail generation but also point to potential additional mechanisms to be further investigated. That future event simulation remains overgeneral even when PTSD symptoms abate highlights the importance of addressing alterations in future thinking in this population.

Keywords Posttraumatic stress disorder · Future thinking · Overgenerality

Autobiographical memory disturbance is a central feature of posttraumatic stress disorder (PTSD) that has been causally linked to the expression of symptoms following trauma exposure (Brewin, 2011; Ehlers & Clark, 2000; Rubin et al., 2008). In many individuals diagnosed with PTSD, memory of the trauma event may lack full contextualization. Trauma memories therefore may remain isolated from the broader autobiographical knowledge base, leading to the repeated intrusion of aspects of the trauma event into awareness. Notably, however, failure to situate memories in their appropriate context extends beyond the trauma event among individuals with PTSD. Extensive evidence suggests that individuals with PTSD have difficulty retrieving detailed specific personal memories that are located in space and time, instead recalling categorical information that applies to an entire class of events or pertains to extended time periods. Such overgeneral recall occurs in response to negative, and especially positive, cues (Moore & Zoellner, 2007; Ono & Devilly, 2016) and correlates with subsequent PTSD symptom severity (Bryant et al., 2007; Harvey et al., 1998; Kleim & Ehlers, 2008).

It has long been recognized that individuals with PTSD may experience an enduring sense of threat long after their exposure to a traumatic event, with global negative implications for how they view the future. Although appraisals of perceived danger have been linked to an inability to properly contextualize the trauma memory (Ehlers & Clark, 2000), the impact of alterations in autobiographical

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memory on future thinking has only recently garnered systematic attention, primarily as a result of cognitive neuroscience research demonstrating that imagining future events relies on processes and neural substrates similar to those involved in remembering past events (Mullaly & Maguire, 2014; Schacter et al., 2008; Szpunar, 2010). Extending findings from the domain of memory to future thinking, Brown et al. (2013) showed that combat veterans diagnosed with PTSD, compared with those without PTSD, generated future events pertaining to the near or distant future in response to neutral cue words that were less temporally specific. A recent study of Rohingya refugees similarly documented a relationship between PTSD symptoms and lack of specificity in future thinking (Khan & Haque, 2022). Extending their focus beyond specificity, Brown and colleagues examined the nature of the information included in the future event descriptions of their combat veterans (Brown et al., 2014). This analysis revealed that, regardless of temporal distance, the PTSD group generated fewer details related to the central event (i.e., internal details) and more details tangential to that event (i.e., external details) than did the no-PTSD group.

In the only study to examine emotional future thinking, Kleim et al. (2014) found that assault and motor vehicle accident survivors diagnosed with PTSD imagined fewer specific events in response to positive, but not negative, cues compared with those without PTSD. Notably, however, specificity in response to negative cues was very low in both groups, possibly due to the brief time participants were given to generate future events. Furthermore, albeit related, specificity and detail are distinct concepts (Hallford et al., 2021), and the nature and quantity of details characterizing future event narratives were not analyzed. Given that a majority of spontaneous future thoughts are emotional in nature (D'Argembeau et al., 2011) and that emotional future simulations serve important functions related to goal pursuit and emotion regulation (Barsics et al., 2016; Wardell et al., 2022), the current study sought to further characterize emotional future thinking in PTSD. We also aimed to identify aspects of the emotional and cognitive profiles of individuals with PTSD that may relate to alterations in future thinking.

First, to assess how representations of future events may be altered in PTSD, we analyzed the details comprising future events generated: (1) in response to positive and negative cue words, and (2) in the near and distant future. In line with Brown et al.'s (2014) findings for future events elicited by neutral cues, we predicted that individuals with a current diagnosis of PTSD would generate fewer internal details than individuals without PTSD. To address whether changes in future thinking are dependent on current PTSD symptomatology, we also included a group of individuals with a history of PTSD who did not express significant current symptoms. This extension of previous research was motivated by the finding that individuals with fully or partially abated PTSD symptoms nonetheless show continued negative appraisal of their trauma memory (Halligan et al., 2003) and evidence suggesting that overgeneral memory may constitute a cognitive vulnerability for PTSD (Bryant & Guthrie, 2007; Lapidow & Brown, 2015).

In considering potential effects of cue valence, we took into account that future-event generation depends not only on the flexible recombination of past memories (Schacter & Addis, 2007) but also on conceptual knowledge about the self (Chessell et al., 2014; D'Argembeau, 2016), whereby the self provides an organizing framework for the search for and construction of a specific event (Conway & Pleydell-Pearce, 2000). Evidence suggests that the extent to which a trauma experience is central to one's identity correlates with the severity of PTSD symptoms (Berntsen & Rubin, 2006; Sutherland & Bryant, 2005). When the trauma becomes a salient point in one's life story, it may lead to cognitive distortions of the self, including negative beliefs, such as self-criticism, helplessness, and hopelessness (Brewin, 2011; Engelbrecht & Jobson, 2020). We predicted that the availability of negative self-beliefs in PTSD would be associated with especially impoverished future events in response to positive cues. Of further relevance given the overlap between PTSD and depressive symptoms, findings of a recent meta-analysis in depression suggest that the association between depressive symptoms and reduced future-thinking specificity may be selective to future events imagined in response to positive cues (Gamble et al., 2019).

With regard to temporal distance, in normal cognition, greater temporal distance is associated with imagining fewer event-specific details (D'Argembeau & Van der Linden, 2004; Race et al., 2011), a finding consistent with the notion that events that are temporally distant are construed at a more abstract level (Trope & Liberman, 2010). This association in normal cognition arguably would lead to the prediction that individuals with current PTSD (vs. no PTSD) will provide fewer internal details primarily when imagining events in the near future, as we would expect both those with and without PTSD to imagine events in the far future in limited detail. Yet, Brown et al. (2014) found no evidence for differential production of internal details in PTSD versus no PTSD as a function of temporal distance. Thus, the comparison of near versus far future events was largely exploratory.

A second goal was to examine the relations between alterations in future thinking and PTSD symptom profiles. We hypothesized that the symptom cluster of avoidance would be associated with the level of internal details in future thinking. Consistent with the notion that avoiding details of a traumatic experience is perceived as a means of reducing emotional distress (Memel et al., 2021; Robinson & Jobson, 2013; Sumner, 2012), functional avoidance has been linked to overgenerality of both trauma and nontrauma memory in PTSD (Sumner, 2012; Williams et al., 2007). Given that details from past events provide the building blocks for future events, we reasoned that greater avoidance might similarly be associated with production of fewer details in imagined future events. Further supporting this prediction, Seligowski et al. (2016) found that thought suppression as an emotion regulation strategy was most strongly linked to the avoidance cluster. Examination of associations between the other symptom clusters and internal detail generation was exploratory.

A third goal was to investigate neurocognitive mechanisms that may be associated with altered future thinking in PTSD. Given that autobiographical memory provides a source of details for future event simulation, we postulated that the same neurocognitive processes required for specific and detailed retrieval from memory might also be critical for detailed future thinking. In line with Williams et al. (2007), we focused on strategic retrieval processes that guide the search through a hierarchy of representations, proceeding from an initial generic description of an event or class of events to construction of a specific event (Conway & Pleydell-Pearce, 2000; Moscovitch, 1992). In particular, we considered processes for which there is already empirical support, including (1) generative processes necessary for initiating and guiding search strategies that ultimately lead to the selection of a specific event (Addis et al., 2016; D'Argembeau et al., 2010) and (2) working memory required to hold in mind and integrate the products of a memory search (Addis et al., 2008; Hill & Emery, 2013). Additionally, because further elaboration of an event requires the retrieval and binding of disparate details into a novel event (Schacter & Addis, 2009), we also assessed relational memory ability, which has similarly been shown to correlate with future event detail (Addis et al., 2008). In light of evidence for alterations in PTSD in executive function (Polak et al., 2012; Woon et al., 2017), including working memory (Schweizer & Dalgeish, 2016; Scott et al., 2015) and verbal fluency (Desrochers et al., 2021; Shandera-Ochsner et al., 2013), and in episodic memory (Petzold & Bunzeck, 2022; Scott et al., 2015), we predicted that more proficient working memory, verbal fluency, and relational memory would be associated with generation of a greater number of event-specific details during future event simulation.

Method

Participants

Participants were 58 trauma-exposed U.S. military war-zone veterans, aged 20 to 60 years, who took part in a larger study that examined different aspects of future cognition in PTSD. Participants were recruited from a registry of veterans at VA Boston Healthcare System, through local flyers, and internet-based recruitment tools. Inclusion criteria required trauma exposure. Participants were excluded if they conveyed lifetime history of psychotic disorder, bipolar I disorder, obsessive compulsive disorder, current (past 3 months) substance use disorder, suicidal ideation, moderate-to-severe traumatic brain injury, or other major neurological disorders (e.g., stroke).

PTSD status was ascertained using the Clinician Administered PTSD Scale for DSM-5 (Weathers et al., 2018), described below. Participants were classified into three groups: 25 individuals who met current criteria for PTSD ($\text{PTSD}_{\text{current}}$); 20 individuals with a lifetime history of PTSD who did not meet current diagnostic criteria ($\text{PTSD}_{\text{past}}$), and 13 individuals who had no lifetime history of PTSD (no PTSD) nor other DSM diagnoses.

Power analysis, using a balanced one-way analysis of variance test (Cohen, 1988) implemented with function pwr.anova.test from the R-package pwr (Champely, 2020), indicated that a sample size of 11 participants per group was required to achieve 80% power to detect an effect size of eta^2 = 0.29 (as per the effect size reported for the group effect in Brown et al., 2014), with alpha threshold = 0.05. All participants provided informed consent. Human subjects considerations were approved by the research oversight committees of VA Boston Healthcare System. Participants were reimbursed \$15/hour for their participation.

Materials

Clinical measures

Trauma exposure was assessed using the Life Events Checklist for DMS-5 (Weathers et al., 2013). PTSD was assessed by using a standardized structural clinical interview, the Clinician Administered PTSD Scale for DSM-5 (CAPS-5; Weathers et al., 2018). In addition to diagnoses, the interview yields summary scores for each of four symptom clusters (intrusions, avoidance, negative alterations in cognitions and mood [NACM], alterations in arousal and reactivity) indicative of symptom severity. Diagnostic classifications were used to examine alterations in detail generation, and symptom cluster scores were used to examine associations with symptom profiles. To capture the expression of symptoms associated with PTSD diagnosis, lifetime CAPS-5 scores were therefore assessed and used for the $\text{PTSD}_{\text{past}}$ group. CAPS-5 scores demonstrated excellent inter-rater reliability (Cronbach's α for total score and cluster scores all >0.92) for a random subset of 10% of interviews that were scored by a second doctoral-level clinical psychologist with expertise in use of the CAPS.

Exclusionary psychopathology criteria were assessed with the Structured Clinical Interview for DSM-5, research version (First et al., 2016). Traumatic brain injury was assessed by using the Boston Assessment of Traumatic Brain Injury-Lifetime (Fortier et al., 2014). We surveyed participants for other exclusionary neurological conditions, which were confirmed by chart review as necessary.

To further characterize the study sample, participants completed the Beck Depression Inventory-II (BDI-II; Beck et al., 1996) as a measure of depression symptom severity. Because of the possible association of PTSD with a sense of foreshortened future, we administered the Future Time Perspective Scale (Husman & Shell, 2008) as a measure of conceptualization of the future. This scale consists of 27 items rated on a 5-point Likert scale that index dimensions of speed (e.g., I always seem to be doing things at the last minute), future extension (e.g., half a year seems like a long time away), value (e.g., what happens in the long run is more important than how one feels right now), and connectedness (e.g., one should be taking steps today to help realize future goals).

Neurocognitive measures

Generative ability was assessed using the Delis-Kaplan Executive Function System (D-KEFS) Verbal Fluency Test (Delis et al., 2001) with scores in the phonemic condition (FAS fluency) as the outcome measure. As measures of working memory, we administered the forward and backward conditions of the Digit Span subtest and the Number-Letter Sequencing subtest, both from the Wechsler Adult Intelligence Scale, 4th Edition (Wechsler, 2008). Relational (episodic) memory was assessed with Verbal Paired Associates from the Wechsler Memory Scale, 4th edition (Wechsler, 2009), with total immediate recall across learning trials and total delayed recall as outcome measures. Age-corrected scaled scores were used for all tests.

Future-thinking paradigm

In line with other studies of future thinking (Addis et al., 2007), we used an adapted autobiographical interview (Levine et al., 2002) in which participants were asked to describe in as much detail as possible a future event in response to each of six positive (*success, joy, wealth, friendship, pleasure, win*) and six negative (*pain, hardship, loneliness, failure, defeat, debt*) cues. Participants were instructed to provide as many details as possible, including spatiotemporal details, perceptual details, and thoughts and feelings pertaining to the imagined event. Half of the cues were set 1 month in the future and the other half 10 years in the future. For each cue, participants were instructed to imagine a discrete, novel event, spanning no more than 24 hours, in which they would be personally involved. The examiner first provided an example related to the word *praise*, and then participants completed a practice trial related to the word *promotion* before engaging in the actual task. They were given 3 minutes to describe each event and responses were audio-recorded. If the participant spoke for less than 3 minutes, they were given one prompt to provide more information (i.e., "Can you tell me more about [event]"). These prompts were meant to promote task motivation across trials, and post-prompt narratives were not analyzed. After each description, participants were asked to verify whether the narrative described a novel event (as opposed to a memory from the past). To gain insight into participants' subjective experience, they additionally were asked to rate on a 7-point scale: (1) the vividness of the imagined event (1 = vague with no details; 7 = vivid and highly detailed), and (2) the emotional valence of the event (−7 = extremely negative; +7 = extremely positive). The assignment of cue words to temporal setting (1 month vs. 10 years) was counterbalanced across participants. Positive and negative cue words were intermixed, but the temporal setting was blocked to avoid the need for task switching.

Narratives were transcribed and segmented into informational bits. Internal details consisted of details pertaining to the main event and were categorized as event, place, time, perceptual, and emotion/thought in accordance with Levine et al.'s (2002) autobiographical interview scoring procedure. External details consisted of details pertaining to discrete events other than the main event or episodes extending in duration beyond 24 hours, as well as personal semantic and general semantic details. A single rater, blind to participant information, scored all the narratives used for the main data analyses. Ratings of the narratives of 20% of the participants by a second rater suggested good to excellent inter-rater reliability for total internal details (Cronbach's α = 0.92), total external details (α = 0.80), and across types of internal details (α = 0.92 for event, α = 0.89 for place, α = 0.95 for time, α = 0.88 for perceptual, and α = 0.85 for thoughts/emotions).

Assessment procedures

All measures were administered by a doctoral level clinical psychologist according to scripted, standardized instructions. Early study participants were tested in person, but because of mandatory safety precautions during the Covid-19 pandemic, the study protocol was subsequently adapted to remote administration via videoconferencing platform. Forty-three participants completed study procedures in person and 15 remotely. For veterans who participated in person, the future-thinking task was administered before the clinical measures in a single session, with the neurocognitive measures administered in the same or subsequent session, depending on the length of the session. For veterans who participated remotely, the future-thinking task, clinical measures and cognitive measures were administered in separate sessions; the future-thinking task was always administered in the first session. Thus, the psychologist was blind to participant status when administering the future-thinking task. All procedures were completed on average in 14.3 days (range = 0–49 days; median = 14).

In instances in which data were collected over several sessions, there was occasional attrition due to nonreturning participants. Nine participants did not complete all sessions and have missing neurocognitive testing data. These participants were included in the main analyses but were excluded from follow-up analyses involving neurocognitive test performance. Additionally, one participant did not complete the Future Time Perspective Scale. Participants generally followed task instructions well, and only a few narratives were described as constituting memories rather than new events (10 narratives across 7 participants). These narratives were excluded from data analyses. On rare occasions, a participant became emotional and elected to skip a cue word (resulting in 12 missing narratives across 6 participants). Due to recorder malfunction, there were additional missing data for 8 narratives across 3 participants.

Analytic approach

Demographic characteristics of the three groups were compared by using analysis of variance (ANOVA) (age, education) or chi-square test (gender). Clinical scores (total CAPS-5, BDI-II, Future Time Perspective scores), and neurocognitive test scores were each compared by using ANOVA.

To assess associations of PTSD status with the number of internal details in imagined future events, linear mixed modeling was employed, using participant and cue word as random factors. The main model included group ($PTSD_{current}$, $PTSD_{past}$, no PTSD), cue valence (positive vs. negative), cue time (1 month vs. 10 years), and their interactions as fixed effects. Random effects included intercepts and cue time slopes for each participant and intercepts for each cue word. (Models with more complex random effect structures yielded singular fit due to the excessive number of parameters). Models were fit with maximum likelihood estimation in the R statistical software (R Core Team, 2019) (package lme 4, Bates et al., 2014). A model comparison approach with systematic removal of nonsignificant fixed-effect interactions was used to select the best-fit model. Goodness of fit was estimated by using Akaike's Information Criterion (AIC; Akaike, 1974), the Bayesian Information Criterion (BIC; Schwarz, 1978), and the amount of variance explained by the fixed effects (R^2 marginal effect sizes, piecewiseSEM R package; Nakagawa & Schielzeth, 2013). Significance of model comparison was evaluated using a Likelihood ratio test with χ^2 distribution. Significance level for each fixed effect was evaluated with a *t*-test by using Satterthwaite's method, as implemented using the *R lme4*-package (Bates et al., 2014). We also assessed the effect of administration modality (in person vs. remotely) on the generation of internal details and included it as fixed effect in the linear mixed model. Because the effect of administration modality was nonsignificant, it was removed from the final model.

To assess whether symptoms of depression may account for any observed effect of group on internal details, an additional linear mixed model was carried out also including BDI-II scores as a fixed effect.

In an ancillary analysis, a similar approach was used to examine associations of PTSD status and the number of external details. Analogous linear mixed modeling analyses also were performed on the participants' ratings of vividness and emotion of their imagined events. The model for emotion ratings included cue valence as random slope, as the fit was not singular due to the sufficiently large effect of cue valence. For each of the linear mixed models, the significance threshold was set at $p = 0.025$ to adjust for the fact that we compared two PTSD groups to the no-PTSD group.

To examine associations between different types of internal details in future events with PTSD symptom clusters (current symptoms for the $PTSD_{current}$ group and past symptoms during their most symptomatic period for the $PTSD_{past}$ group) and neurocognitive performances, we used partial least squares (PLS) correlation. PLS capitalizes on a multivariate technique that assesses the relationships between two sets of variables, organized in two matrices x and y, by modeling their covariance (Abdi & Williams, 2013; Krishnan et al., 2011). The x-matrix consisted of the scores on the CAPS symptom clusters and neurocognitive tests, with additional inclusion of scores on the Future Time Perspective Scale. The y-matrix consisted of the number of details within each of the event, place, time, perception, and thought/emotion categories. Relationships among measures are expressed as latent variables, akin to eigenvectors in principal components analysis. The approach makes no previous assumptions about the relations among the measures, is robust to multicollinearity, and because it involves a single analytic step, does not require correction for multiple comparisons.

The PLS analysis was conducted using the tepPLS function in the R-package TExPosition (Beaton et al., 2013), including data from participants in the $PTSD_{current}$, $PTSD_{past}$, and no-PTSD groups for whom there was no missing data. The matrix of cross-covariance between x-and y-variables was decomposed using singular value decomposition. PLS computes the inertia of that matrix to estimate the total amount of cross-covariance and, using the singular eigenvectors, creates latent variables that characterize the largest amount of information shared in the x and y matrices. The statistical significance of the omnibus inertia and latent variables were determined using a permutation test, via random shuffling of columns of the x and y matrices independently (n = 6,000 iterations), implemented with the R-function perm4PLSC as part of package data4PCCAR (Abdi & Beaton, 2023). *P*-values, calculated as the probability that the permutated inertia and singular values exceed the observed values, were considered significant if <0.05 (Abdi & Williams, 2013). For each significant latent variable, contributions of the x- and y-measures were assessed by examining their saliences (akin to loadings). To assess the reliability of the saliences, the salience standard errors were estimated using a bootstrap test, implemented with the R-function Boot4PLSC (Abdi & Beaton, 2023). Specifically, 10,000 bootstrap samples were generated using sampling with replacement of the observations in x and y, keeping fixed assignment of observations (Efron & Tibshirani, 1986). Ratios of salience to bootstrap standard errors were calculated, and, akin to z-scores, the corresponding saliences were considered reliable if >2 (Krishnan et al., 2011).

To examine whether relations between internal details and PTSD symptom clusters, Future Time Perspective scores, and neurocognitive performances differed depending on whether PTSD symptoms were expressed currently or in the past, two ancillary PLS analyses were conducted. One included data from participants in the $\text{PTSD}_{\text{current}}$ and no-PTSD groups and the second included data from participants in the $\text{PTSD}_{\text{past}}$ and no-PTSD groups. Because the results of these two analyses were not markedly dissimilar from one another and from the main PLS analysis, they are provided in the Appendix.

Because it is well established that low education increases the likelihood of developing PTSD (Sayed et al., 2015), analyses did not control for differences in education level across groups (Miller & Chapman, 2001).

Results

Demographic, clinical, and neurocognitive group characteristics

Sample descriptives are presented in Table 1 and clinical and neurocognitive characteristics in Table 2. The groups did not significantly differ in age or gender distribution, but the no-PTSD group reported more years of education than the other two groups. In terms of current psychological status, aside from PTSD symptoms, the $\text{PTSD}_{\text{current}}$ group also displayed more severe depressive symptoms than the $\text{PTSD}_{\text{past}}$ and no-PTSD groups. Current PTSD symptoms, albeit minimal among participants reporting past PTSD, were elevated in the $\text{PTSD}_{\text{past}}$ compared with the no-PTSD group. The future time perspective profiles of the groups differed significantly only in future connectedness, with

Table 1 Sample characteristics

Characteristic	Overall N = 58			$\text{PTSD}_{\text{current}}$ n = 25			$\text{PTSD}_{\text{past}}$ n = 20			No PTSD n = 13			Test Statistics[a]
	No. or *M*	% or (*SD*)	Range	No. or *M*	% or (*SD*)	Range	No. or *M*	% or (*SD*)	Range	No. or *M*	% or (*SD*)	Range	
Gender, no.													$\chi^2(2) = 1.0, p = .596$
Females	9	16%		4	16%		2	10%		3	23%		
Males	49	84%		21	84%		18	90%		10	77%		
Race/Ethnicity, no.													
White	44	76%		18	72%		15	75%		11	85%		$\chi^2(2) = 0.8, p = .685$
Latino	8	14%		5	20%		2	10%		1	8%		$\chi^2(2) = 1.5, p = .482$
Asian	2	3%		1	4%		1	5%		0	0%		$\chi^2(2) = 0.6, p = .729$
Black	2	3%		1	4%		1	5%		0	0%		$\chi^2(2) = 0.6, p = .729$
Multiracial	2	3%		0	4%		1	5%		1	0%		$\chi^2(2) = 1.7, p = .419$
Age, y	39.3	(9.7)	22-60	38.7	(9.6)	27-60	40.7	(10.9)	22-58	38.5	(8.3)	27-55	$F(2,55) = 0.3, p = .763$
Education, y	15.0	(2.1)	10-20	14.7*	(2.4)	10-20	14.6*	(1.9)	12-18	16.5	(1.5)	13-19	$F(2,55) = 4.2, p = .020$

[a] Test statistics reflect comparisons across diagnostic groups

Table 2 Clinical and neurocognitive characteristics

Assessment	$PTSD_{current}$		$PTSD_{past}$		No PTSD		Test Statistics[a]
	No. or *M*	% or *(SD)*	No. or *M*	% or *(SD)*	No. or *M*	% or *(SD)*	
PTSD Assessment							
Sample, no.	25		20		13		
Criterion A Traumatic Event, no.							
Combat related	18	72%	14	70%	7	54%	
Sexual assault	2	8%	1	5%	0	0%	
Physical assault	0	0%	3	15%	0	0%	
Fire	2	8%	0	0%	2	15%	
Transportation accident	0	0%	1	5%	2	15%	
Sudden violent death	2	8%	1	5%	0	0%	
Severe human suffering	1	4%	0	0%	1	8%	
Serious accident	0	0%	0	0%	1	8%	
CAPS-5, current							
No. symptom cluster criteria met, *M*	4.00	(0.0)	1.1	(0.9)	0.2	(0.6)	
Total score, *M*	35.9***	(10.3)	8.9*	(5.9)	1.9	(3.1)	$F(2,55) = 108.6, p < .001$
Intrusions score, *M*	9.3***	(3.2)	3.0*	(2.0)	0.7	(1.2)	$F(2,55) = 63.9, p < .001$
Avoidance score, *M*	4.4***	(1.7)	0.8	(1.2)	0.2	(0.4)	$F(2,55) = 59.7, p < .001$
NACM score, *M*	11.6***	(5.0)	1.8	(2.9)	0.2	(0.6)	$F(2,55) = 56.6, p < .001$
Arousal score, *M*	10.6***	(3.5)	3.3*	(3.0)	0.9	(1.6)	$F(2,55) = 56.3, p < .001$
Clinical Assessments							
Sample, no.	25		20		13		
DSM-5 Depressive disorders, no.	10*	40%	1	5%	0	0%	$\chi^2(2) = 12.8, p = .002$
DSM-5 Anxiety disorders, no.	10*	40%	3	15%	0	0%	$\chi^2(2) = 8.8, p = .012$
Psychotropic Medication, no.	13	52%	8	40%	2	15%	$\chi^2(2) = 4.8, p = .091$
BDI-II, *M*	22.2***	(8.9)	9.9	(8.8)	5.4	(6.7)	$F(2,55) = 21.0, p < .001$
Future Time Perspective Scale							
Sample, no.	24		20		13		
Connectedness, score, *M*	45.2**	(6.9)	50.3	(5.9)	51.0	(4.5)	$F(2,54) = 5.6, p = .006$
Value, score, *M*	21.2	(4.2)	22.8	(3.6)	23.8	(4.0)	$F(2,54) = 2.0, p = .151$
Speed, score, *M*	9.42	(2.8)	8.40	(2.5)	8.23	(2.9)	$F(2,54) = 1.1, p = .336$
Extension, score, *M*	6.29	(1.0)	5.65	(0.9)	6.00	(0.6)	$F(2,54) = 2.9\ \ p = .062$
Neurocognitive Measures							
Sample, no.	20		16		13		
FAS Fluency, scaled score *M*	11.4	(3.7)	12.6	(2.7)	13.2	(4.4)	$F(2,46) = 1.0, p = .362$
Digit Span Forward, scaled score, *M*	9.4	(2.4)	9.4	(2.8)	10.5	(3.8)	$F(2,46) = 0.6, p = .555$
Digit Span Backward, scaled score, *M*	9.7	(3.1)	10.1	(2.8)	11.0	(3.3)	$F(2,46) = 0.7, p = .487$
Letter-Number Sequencing, scaled score, *M*	9.1*	(1.7)	9.6*	(2.4)	11.5	(3.6)	$F(2,46) = 4.0, p = .026$
Paired Associates immediate recall, scaled score, *M*	10.0[b]	(2.5)	10.6	(2.9)	12.2	(3.0)	$F(2,46) = 2.5, p = .09$
Paired Associates delayed recall, scaled score, *M*	10.8	(2.1)	10.8	(2.6)	12.3	(2.1)	$F(2,46) = 2.3, p = .114$

CAPS-5 = Clinician Administered PTSD Scale for DSM-5. BDI-II: Beck Depression Inventory -II. NACM = negative alterations in cognition and mood. [a]Test statistics reflect comparisons across diagnostic groups. Asterisks indicate significant differences in the $PTSD_{current}$ or $PTSD_{past}$ groups compared to the no-PTSD group (*p < .05, ** p < .01, *** p < .001). [b]indicates that the three-group omnibus ANOVA was not significant, but a two-group comparison yielded a significant difference compared to the no-PTSD group

significantly lower scores in the $PTSD_{current}$ group compared with the $PTSD_{past}$ and no-PTSD groups. Age-corrected neurocognitive test scores generally did not differ across groups, except that both PTSD groups performed less well on the Letter-Number Sequencing subtest than the no-PTSD group. Additionally, the $PTSD_{current}$ group performed less well than the no-PTSD group on the Verbal Paired Associates immediate recall subtest.

Future event details

Results of the linear mixed modeling analysis carried out on internal details revealed a significant fixed effect of group. Specifically, in comparison to the no-PTSD group, both the $PTSD_{current}$ ($\beta = -10.8$, $SE = 4.5$, $t(57.9) = -2.4$, $p = 0.018$) and $PTSD_{past}$ ($\beta = -10.8$, $SE = 4.6$, $t(57.7) = -2.3$, $p = 0.023$) groups generated fewer internal details (Fig. 1). The model that included fixed effects of group, cue time, and cue valence ($AIC = 5{,}308.5$, $BIC = 5{,}353.6$, R^2 *marginal* $= 0.081$) provided a significantly better fit ($\chi^2(2) = 6.5$, $p = 0.039$) than the same model without group ($AIC = 5{,}311.0$, $BIC = 5{,}347.0$, R^2 *marginal* $= 0.016$). Results also showed a significant fixed effect of cue time, with narratives one month into the future containing more internal details than those 10 years into the future ($\beta = 4.3$, $SE = 1.2$, $t(56.9) = 3.6$, $p < 0.001$). There was no significant fixed effect of cue valence ($\beta = 1.5$, $SE = 1.7$, $t(11.1) = 0.9$, $p = 0.397$). Contrary to our hypothesis, the models with two-way interactions did not provide better fit ($AIC = 5310.8$, $BIC = 5373.8$, R^2 *marginal* $= 0.091$, $\chi^2(4) = 5.7$, $p = 0.221$) and featured a nonsignificant group × cue valence ($PTSD_{current}$: $\beta = -1.6$, $SE = 2.2$, $t(543.3) = -0.8$, $p = 0.454$; $PTSD_{past}$: $\beta = -0.2$, $SE = 2.3$, $t(541.5) = -0.084$, $p = 0.933$) and group x cue time interaction ($PTSD_{current}$: $\beta = -5.0$, $SE = 3.0$, $t(56.4) = -1.7$, $p = 0.097$; $PTSD_{past}$: $\beta = 0.5$, $SE = 3.1$, $t(57.1) = 0.2$, $p = 0.872$).

To examine whether depression could explain the effect of group on internal details, an ancillary analysis was run that also included BDI-II as a fixed effect. Results showed no effect of BDI-II ($\beta = 0.2$, $SE = 0.2$, $t(57.9) = 0.8$, $p = 0.434$), whereas the effect of group remained significant ($PTSD_{current}$: $\beta = -13.6$, $SE = 5.6$, $t(58.1) = -2.4$, $p = 0.019$; $PTSD_{past}$: $\beta = -11.5$, $SE = 4.7$, $t(57.7) = -2.5$, $p = 0.017$). The model that included fixed effects of group, BDI-II, cue time, and cue valence ($AIC = 5{,}309.9$, $BIC = 5{,}359.4$, R^2 *marginal* $= 0.086$) provided a significantly better fit ($\chi^2(2) = 6.9$, $p = 0.032$) than the same model without group ($AIC = 5{,}312.8$, $BIC = 5{,}353.3$, R^2 *marginal* $= 0.018$), suggesting that the association of PTSD with internal details is present over and beyond any contribution from depression.

Linear mixed modeling analysis performed on external details yielded a fixed effect of group that was small and did not survive correction for multiple comparisons for the $PTSD_{current}$ compared with the no-PTSD group ($\beta = -2.6$, $SE = 1.3$, $t(58.1) = -2.1$, $p = 0.043$) and was nonsignificant for the $PTSD_{past}$ group ($\beta = -2.4$, $SE = 1.3$, $t(57.7) = -1.8$, $p = 0.078$). The overall fit of the model with group, cue time, and cue valence ($AIC = 3{,}843.0$, $BIC = 3{,}888.0$, R^2 *marginal* $= 0.043$) was not significantly better than the same model without group ($AIC = 3{,}843.5$, $BIC = 3{,}879.5$, R^2 *marginal* $= 0.004$, $\chi^2(2) = 4.5$, $p = 0.106$); and the model with group × cue time and group × cue valence interactions did not provide better fit ($AIC = 3{,}850.3$, $BIC = 3{,}913.3$, R^2 *marginal* $= 0.046$, $\chi^2(4) = 0.8$, $p = 0.942$).

Vividness and emotion ratings

Linear mixed modeling analysis of the vividness ratings with fixed effects of group, cue valence, and cue time revealed no significant effect of group, as indicated by the parameter estimates ($PTSD_{current}$: $\beta = -0.4$, $SE = 0.3$, $t(57.9) = -1.3$, $p = 0.189$; $PTSD_{past}$: $\beta = -0.3$, $SE = 0.3$, $t(57.5) = -1.0$, $p = 0.336$) and by a fit of the model with group ($AIC =$

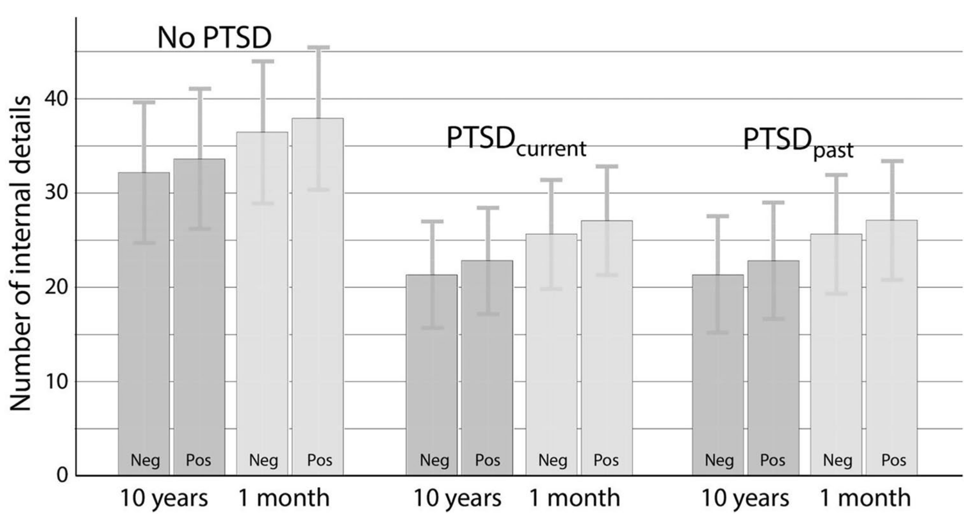

Fig. 1 Mean number of internal details produced per narrative, broken down by group, cue valence (Neg = Negative, Pos = Positive), and cue time (10 years, 1 month). *Note.* The mean estimates were calculated using linear mixed modeling, with model comprising fixed effects for group, cue valence, and cue time. The error bars represent the 95% confidence interval of the estimates

2,053.3, *BIC* = 2,098.3, R^2 *marginal* = 0.027) that was not better than for the model without group (*AIC* = 2,051.0, *BIC* = 2,087.0, R^2 *marginal* = 0.014, $\chi^2(2) = 1.7$, $p = 0.418$). The fixed effects of cue valence and cue time were both significant, with greater vividness endorsed across groups for positive compared with negative cues ($\beta = 0.3$, $SE = 0.1$, $t(10.3) = 3.1$, $p = 0.011$), and for events 1 month versus 10 years into the future ($\beta = 0.2$, $SE = 0.1$, $t(55.4) = 2.0$ $p = 0.047$). A model that included group × cue time and group × cue valence interactions did not provide better fit (*AIC* = 2,059.4, *BIC* = 2,122.4, R^2 *marginal* = 0.029, $\chi^2(4) = 1.9$, $p = 0.755$).

Linear mixed modeling analysis on emotion ratings confirmed a large, expected effect of cue valence (positive vs. negative: $\beta = 6.6$, $SE = 0.6$, $t(20.5) = 10.2$, $p < 0.001$) but no effect of cue time ($\beta = -0.1$, $SE = 0.1$, $t(55.2) = -0.3$, $p = 0.765$). There was a small effect of group with individuals in the $\text{PTSD}_{\text{past}}$ group providing slightly higher emotion ratings than those in the no-PTSD group, but that effect did not survive correction for multiple comparisons ($\beta = 0.8$, $SE = 0.4$, $t(53.9) = 2.0$, $p = 0.048$); there was no significant difference between those in the $\text{PTSD}_{\text{current}}$ and no-PTSD groups ($\beta = 0.2$, $SE = 0.4$, $t(54.6) = 0.6$, $p = 0.582$). The overall fit of the model with group, cue time, and cue valence (*AIC* = 3,344.1, *BIC* = 3,402.6, R^2 *marginal* = 0.514) was not significantly better than the same model without group (*AIC* = 3,344.7, *BIC* = 3,394.2, R^2 *marginal* = 0.510, $\chi^2(2) = 4.6$, $p = 0.103$); and the model including group × cue time and group × cue valence interactions did not provide better fit (*AIC* = 3,349.0, *BIC* = 3,425.5, R^2 *marginal* = 0.518, $\chi^2(4) = 3.1$, $p = 0.536$).

Correlates of internal detail production

Results of the PLS-correlation, conducted to explore relations between different types of internal details and scores on the CAPS-5 subscales, Future Time Perspective Scale, and neurocognitive testing, revealed a significant overall association among the variables (inertia = 2.7, $p < 0.001$). Singular value matrix decomposition suggested that the association was best explained by one latent variable (eigenvalue = 2.23, $p < 0.001$), accounting for 83.1% of the variables' covariance. The second latent variable was not significant (eigenvalue = 0.26, $p = 0.933$, 9.6% covariance) and therefore was not interpreted.

The loadings of the x- and y-measures on the principal latent variable are presented in Fig. 2, illustrating their relative contributions to the overall amount of cross-covariance. Among the y-measures, types of internal details categorized as event, place, and perceptual details were found to be reliable contributors (salience to standard error ratios: $z = 2.8$, 3.4, and 2.9, respectively). By contrast, time and thought/emotion details were not found to be reliable contributors ($z = 0.0$ and 0.9, respectively). Simple descriptive and group comparison statistics for the various types of internal details are presented in Table 3 and indicate significant group differences for event, place, and perceptual details, but not for time and thought/emotion details. Among the x-measures, all CAPS-5 subscales were found to be inversely associated with production of internal details. Contributions were found to be reliable for scores on the avoidance ($z = -2.7$), NACM ($z = -2.5$), and arousal ($z = -2.1$) symptom subscales. Scores on the intrusion symptoms subscale were below the reliability threshold ($z = -1.7$). Among the Future Time Perspective scales, the only dimension that contributed reliably and positively to the latent variable was future value (z = 2.6). Contributions from the other dimensions were not reliable, including future connectedness (z = 0.2), speed (z = −0.1), and future extension (z = 0.0). All neurocognitive test scores were positively associated with internal details. However, the only measure that contributed reliably to the latent variable was Paired Associates delayed recall ($z =$

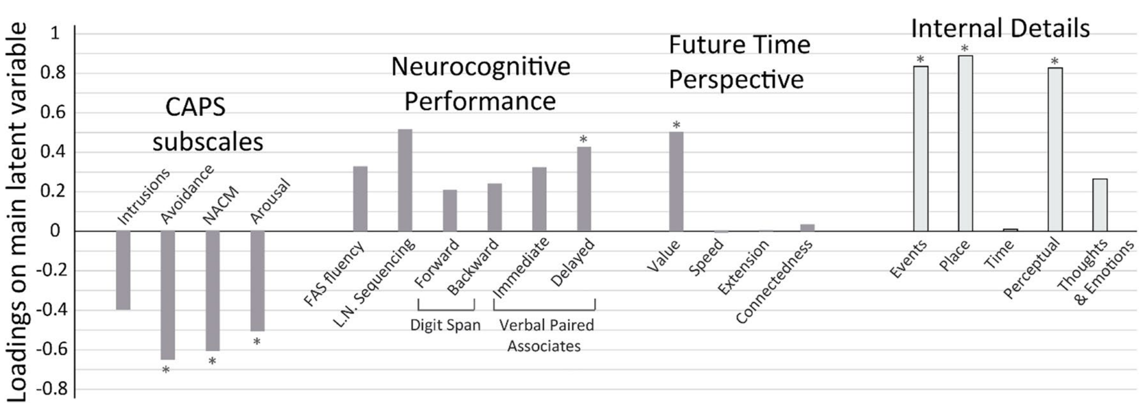

Fig. 2 Loadings on the PLS primary latent variable of the number of internal details categorized by type (y-measures) and of the CAPS subscale scores, Future Time Perspective scores, and neurocognitive test performance measures (x-measures). *Note.* Asterisks indicate measures that were deemed reliable contributors to the primary latent variable (salience to standard error ratios z ≥ 2.0)

Table 3 Number of internal details for each group as a function of detail type

Type of Internal details	$PTSD_{current}$ n = 25		$PTSD_{past}$ n = 20		No PTSD n = 13		Test Statistics[a]
	M	*SD*	*M*	*SD*	*M*	SD	
Event	12.9	6.2	14.1	9.4	20.0	9.0	$F(2,55) = 3.4$, $p = .039$
Place	2.2	1.6	1.9	1.2	3.6	2.1	$F(2,55) = 4.9$, $p = .011$
Time	0.67	0.74	0.61	0.44	0.86	0.50	$F(2,55) = 0.7$, $p = .506$
Perceptual	1.9	1.5	1.5	1.2	3.2	2.4	$F(2,55) = 4.4$, $p = .017$
Thoughts/Emotions	6.0	3.0	6.6	4.7	7.7	3.9	$F(2,55) = 0.8$, $p = .436$

[a]Test statistics reflect comparisons across diagnostic groups

2.0). Contributions for FAS fluency ($z = 1.6$), Letter-Number Sequencing ($z = 1.5$), Paired Associates immediate recall ($z = 1.5$), Digit Span backward ($z = 1.1$), and Digit Span forward ($z = 0.8$) were below the reliability threshold.

Discussion

Our examination of imagined future events in response to emotional cues extends earlier studies of future thinking in PTSD in several ways. Whereas previous work has demonstrated that individuals with PTSD produce fewer internal (i.e., event-specific) details than those without PTSD when generating future events in response to neutral cue words (Brown et al., 2014), our results revealed a similar pattern in response to emotional cue words, both positive and negative. Moreover, this reduction in internal details was seen not only in individuals with current PTSD, but also in those with a history of PTSD who expressed only minimal current symptoms. Extending previous work, we also examined how the richness of future events was related to symptom severity (current for the current PTSD group and past for the group with history of PTSD) within each PTSD symptom cluster. Symptom severity for all PTSD clusters was inversely related to generation of internal details, but with the association relatively weaker for intrusion symptoms. Finally, as the first study to examine neurocognitive processes associated with future thinking characteristics in PTSD, results demonstrated that a measure of episodic memory was inversely related to generation of internal details, whereas measures of working memory or generative ability were not.

Reduced event-specific details in PTSD across positive and negative future events

Our finding that an association of PTSD with event-specific details in imagined future events was present regardless of cue valence stands in contrast to the results of Kleim et al. (2014), who observed less specificity in future thinking in their PTSD group only in response to positive cues. This inconsistency in findings likely reflects differences in the opportunity to elaborate on the imagined event, as our study provided a much longer response time than did Kleim et al. (maximum of 3 vs. 1 minute). Thus, even though individuals with PTSD may be able to generate negative events that are temporally specific, these events are nonetheless less rich in episodic detail. In this context, it is interesting that participants' subjective judgments of vividness did not differ as a function of PTSD, arguing against the possibility that those with PTSD imagined future events that were inherently phenomenologically less rich.

Contrary to our prediction, the paucity of internal details observed in those with PTSD was not exacerbated for positive cue words. It is possible that although distorted cognitions about oneself and the world make negative content more available, such content nonetheless was not expressed in imagined future events in an attempt to reduce emotional distress. Consistent with this notion, subjective ratings of valence did not differ across groups. Of note, valence did not affect detail generation in those without PTSD, but findings on the effect of valence on detail generation in studies of normal cognition have been mixed (Acevedo-Molina et al., 2020; De Vito et al., 2015; Puig & Szpunar, 2017). A bias toward positive events has been demonstrated for other aspects of future thinking, such as their perceived likelihood (Lalla & Sheldon, 2021) or memorability (Szpunar et al., 2012). It will be informative for future studies to examine whether valence moderates these aspects of future thinking in PTSD.

A limitation of the current study is that we did not assess future thinking in response to neutral cues. Although Brown et al. (2014) found that individuals with PTSD, compared with those without PTSD, generated fewer details in future events generated in response to neutral cues, it remains possible that emotional cues, regardless of valence, would yield a larger group difference than neutral cues, as emotional cues likely elicit greater levels of arousal. It has been suggested that arousal facilitates the binding of event details into a coherent event (Mather & Sutherland, 2011). This benefit may not extend to individuals with PTSD given their difficulty with relational memory processes.

Alterations in future thinking associated with past PTSD

Production of fewer internal details was observed not only in individuals with current PTSD but also in those with lifetime PTSD who do not express significant current symptoms, even though the current clinical presentation of these groups differed notably. Current depression symptoms were no higher in the past PTSD group than in trauma-exposed controls, contrasting with the presentation of those with current PTSD. These findings provide compelling evidence that alterations in future thinking are not merely the result of current depression symptoms but instead are intrinsically linked to a history of PTSD, a conclusion additionally supported by the finding that group differences in internal details remained even when depression symptoms were taken into account. Furthermore, whereas the future time perspective of individuals with current PTSD showed reduced connectedness with the present, this was not the case for those with past PTSD, suggesting that the tendency to make connections between present activities and future goals or outcomes and the richness of future event representations are not inherently linked.

Because our study was cross-sectional, we cannot address the causal relationship between PTSD and alterations in future thinking. Within the domain of autobiographical memory, evidence suggests that overgenerality may be a factor that contributes to vulnerability to PTSD following trauma exposure (Lapidow & Brown, 2015). It is possible that overgenerality in future thinking, directly or indirectly because of its dependence on information from autobiographical memory, similarly functions as a risk factor for the occurrence of PTSD. Alternatively, but not mutually exclusive, it is possible that a cognitive bias towards overgeneral future thinking develops in response to PTSD but persists even when symptoms abate, possibly because avoidance of imagining the future in detail is perceived as a strategy to keep symptoms at bay. In this regard, our future thinking results contrast with those for autobiographical memory, where PTSD symptom abatement has been associated with an increase in the generation of specific memories (Sutherland & Bryant, 2007). Future studies directly comparing autobiographical memory and future thinking before and after treatment of PTSD are needed to elucidate the distinct ways in which performance in each of these cognitive domains may relate to PTSD symptom reduction.

Clinical and cognitive profiles associated with reduced internal details

Consistent with our hypothesis, the number of internal details was inversely related to the severity of avoidance symptoms. This finding extends previous work in PTSD on the relationship between functional avoidance and event detail from autobiographical memory to future thinking, consistent with the notion that information from memory provides relevant content for the imagination of future events. In line with theorizing by Williams et al. (2007), we propose that as a means of regulating potential emotional distress, specification of the imagined event is truncated resulting in a lack of specific details (Conway & Pleydell-Pearce, 2000; Williams et al., 2007).

Associations of generation of internal details with other symptom clusters were exploratory and therefore not predicted a priori but are not surprising given the high correlation among PTSD symptom clusters (Miller et al., 2013). The negative association of internal details with the severity of NACM symptoms aligns with findings in the literature on depression, where reduced specificity of future thinking has consistently been demonstrated (Gamble et al., 2019; Hallford et al., 2018). This may reflect the contribution of dysphoric symptoms to the NACM cluster. Notably, in their study of future thinking in patients with depression, Addis et al. (2016) observed a paucity of event details not only in individuals with current depression but also in those in remission, akin to our finding in participants with past PTSD. However, whereas depression has been associated with reduced future event details primarily in response to positive cues (Gamble et al., 2019), in PTSD this association extends to both positive and negative cues. Mechanisms underlying the association between internal details and arousal and reactivity symptoms are less obvious, and future work will be required to elucidate them.

With regard to the conceptualization of the future, only valuation of the future was associated with the generation of internal details. As the value dimension of the Future Thinking Perspective Scale has been operationalized as the importance individuals place on future goals (De Volder & Lens, 1982), this finding aligns with other work demonstrating that personal goals play a central role in future thinking and facilitate the construction of future events (D'Argembeau & Mathy, 2011). Correspondingly, the personal relevance of future events has been associated with event specificity (Cole & Berntsen, 2016) and sense of pre-experiencing (D'Argembeau & Van der Linden, 2012).

With regard to the neurocognitive measures, we found that delayed recall of verbal paired associates—a task on which individuals with PTSD commonly show impaired performance (Petzold & Bunzeck, 2022; Scott et al., 2015)—was associated with a reduction in internal details. This finding lends support to the notion that overgenerality of future thinking in PTSD reflects in part the demands on relational memory processes that are drawn upon when details from memory are recombined in novel ways to construct a future event (Schacter & Addis, 2009). Contrary to our hypothesis, neither verbal fluency nor our measures of working memory were reliably associated with internal details. Examining future thinking in individuals with depression, Addis et al. (2016) found that semantic clustering scores but not verbal fluency scores were related to event specificity. Arguably, semantic clustering may provide a more sensitive measure of the strategic demands associated with the organized search of the contents of memory. With regard to working memory, in a study of normal cognition, Hill and colleagues (2013) found that measures of working memory were related to the initial construction of a future event (as measured by specificity ratings), but not to the elaboration of event details. The lack of a significant relationship with working memory in our study may likewise reflect our focus on event elaboration. Alternatively, it is possible that the working memory demands associated with imagining future emotional events were not well captured by the working memory tests we employed. A methodological limitation of our study is that we used only tasks with neutral information as memoranda. In light of findings indicating that individuals with PTSD have particular difficulty employing working memory in emotion-related contexts (Schweizer & Dalgleish, 2011, 2016), this possibility deserves further exploration.

Associations between internal details and the clinical and neurocognitive measures were specific to event, perceptual, and location details. Given that event details that describe the individuals and happenings associated with a future event comprise by far the most common details in future event descriptions, this association was not surprising. The association of perceptual details is consistent with the proposed role of avoidance symptoms, as it is the sensory-perceptual features of an event that give rise to the phenomenological sense of pre-experiencing of that event (D'Argembeau & Van der Linden, 2012)—a sense that may be suppressed in an attempt to avoid unpleasant emotions. Notably, details reflecting thoughts and emotions pertaining to the event did not show a similar association, likely reflecting the fact that these details are not necessarily anchored to a concrete event and do not inherently imply a sense of pre-experiencing.

Neurobiological underpinnings

Cognitive neuroscience studies suggest that a core network of brain regions, comprising regions in the medial temporal lobe, posterior cingulate, medial prefrontal cortex, and lateral temporal and parietal regions—regions that largely correspond to the default mode network—is engaged during event construction, whether recollection of past events or generation of future events (Benoit & Schacter, 2015). Although no studies to date have directly examined neural substrates associated with future thinking in PTSD, evidence regarding neural alterations associated with PTSD is informative. There is compelling evidence that PTSD is associated with reduced functional connectivity in the default network (Koch et al., 2016). Furthermore, in a study examining whether PTSD impacts the medial prefrontal and medial temporal subsystems of the default mode network differentially (Miller et al., 2017), we observed reduced functional connectivity that was selective to connections between posterior cingulate, one of the midline core regions of the default mode network, and the medial temporal subsystem. We also found that this reduced connectivity was associated with avoidance/numbing symptoms. Given the association between overgeneral memory and avoidance (Schonfeld et al., 2007), we postulated that alterations in a posterior cingulate-hippocampal pathway important for autobiographical memory retrieval might underlie the tendency for overgeneral memory in PTSD. It is possible that the same pathway is implicated in future thinking in PTSD. Evidence suggests that hippocampal activity during future event generation increases both with the amount of detail and demands on recombination (Addis & Schacter, 2008). The association between internal detail and relational processes observed in the current study suggests that altered hippocampal function and/or connectivity may be responsible, at least in part, for overgeneral future thinking in PTSD.

It is possible that the medial prefrontal subsystem of the default mode network is also implicated in future thinking alterations in PTSD. The medial prefrontal subsystem is critical for self-referential processing and the assignment of affective meaning (Andrews-Hanna et al., 2010; Schienle et al., 2014), processes important for autobiographical recollection and future event generation. Examining the large-scale networks associated with autobiographical memory retrieval in PTSD, St. Jacques et al. (2013) observed reduced engagement of the medial prefrontal network in those with PTSD compared with those without PTSD. This finding may indicate a failure to engage this subsystem during autobiographical memory retrieval and, by extension, may similarly be altered during future event generation. Alternatively, however, it also could indicate continued engagement of this subsystem during baseline periods, due to continued reflection on previously retrieved memories.

Implications and future directions

Our study examined future thinking in an overwhelmingly male sample of veterans, who primarily experienced combat-related trauma. As such, the generalizability of our findings remains to be determined. Nonetheless, our finding that veterans with lifetime PTSD experience difficulty in imagining the future in detailed fashion has important functional implications. Considerable evidence suggests that detailed future thinking can benefit decision making and problem solving (Schacter et al., 2017). For instance, future event simulation has been found to reduce temporal discounting—the tendency to choose smaller immediate rewards over larger delayed rewards (Benoit et al., 2011; Peters & Buchel, 2010). Notably, increased temporal discounting has recently been documented in individuals with PTSD (Bryan & Bryan, 2021); whether this is related to alterations in future thinking will be an informative avenue for future study.

Future thinking also serves an important role in emotion regulation (Barsics et al., 2016; Wardell et al., 2022). Imagining a positive future can contribute to a more positive self-concept (MacLeod & Conway, 2007) and enhanced well-being (Gamble et al., 2021). Perhaps less appreciated, imagining future negative events also may be adaptive, allowing one to take appropriate steps to avoid an undesirable outcome or to adopt effective coping strategies to manage such a result (Jing et al., 2016; Miloyan et al., 2016). Paradoxically, the overgenerality in future thinking in individuals with PTSD, albeit born from an attempt to manage distress, may rob them of these benefits of future thinking, thus contributing to the maintenance of their symptoms.

Given the multiple adaptive functions of future thinking, an important question concerns whether it is feasible to augment detailed future thinking in PTSD. Laboratory studies have demonstrated that a brief specificity induction consisting of a video followed by an interview about details therein can improve detail generation in a subsequent future thinking task (Madori et al., 2014). Building on this evidence with the intent of inducing long-lasting change, Hallford et al. (2020) conducted a two-session, manualized, group training in a heterogeneous group of individuals without psychopathology. Relative to a waitlist control group, the intervention group showed improvements in the specificity and self-ratings of detail of future events generated 2 weeks after intervention, although objective ratings of detail were not obtained. Whether this approach can benefit individuals with PTSD remains to be determined. In the only intervention study of individuals with PTSD, Brown et al. (2016) focused on the content of future thoughts rather than their richness. They found that individuals with PTSD who participated in a high self-efficacy induction, wherein they were asked to recall three memories demonstrating self-efficacy, generated future events that contained more self-efficacious statements than those with PTSD in a control condition. The intervention also led to better social problem solving. Assessment of the efficacy and longevity of such interventions in PTSD requires further study, but these approaches hold promise that both the richness and content of future thinking are amenable to improvement, with the potential for concomitant reduction in PTSD symptoms.

Appendix

Supplementary PLS analyses

To examine whether associations between types of internal details (y-variables) and PTSD symptom clusters, Future Time Perspective scores, and neurocognitive performances (x-variables) differed depending on whether PTSD symptoms were expressed currently or in the past, we performed two separate PLS analyses, one including participants in the $PTSD_{current}$ and no-PTSD groups, the second including participants in the $PTSD_{past}$ and no-PTSD groups. Current PTSD symptom scores were entered for the $PTSD_{current}$ group and past symptoms during their most symptomatic period for the $PTSD_{past}$ group.

$PTSD_{current}$ and no-PTSD

Results revealed a significant association among the variables (inertia = 2.9, p = .026), which was best explained by one latent variable (eigenvalue = 2.34, p < .001) that accounted for 79.6% of the variables' covariance. Among the y-variables, types of internal details categorized as event, place, and perceptual details were found to be reliable contributors (salience to standard error ratios: z = 2.4, 3.0, and 2.6, respectively). By contrast, time and thought/emotion details were not found to be reliable contributors (z = -0.4 and 0.6, respectively). Among the x-variables, all CAPS-5 subscales were inversely associated with production of internal details. Contributions were reliable for scores on the avoidance subscale (z = -3.0) and NACM subscale (z = -2.0). Scores on the arousal and intrusion subscales were below the reliability threshold (z = -1.6 and -1.5, respectively). Among the Future Time Perspective scales, only future value contributed reliably and positively to the latent variable (z = 4.1). Contributions of future connectedness (z = 0.1), speed (z = -0.6) and future extension (z = -1.0) were not reliable. Among neurocognitive measures, the only measure that reliably contributed to the latent variable was Paired Associates delayed recall (z = 2.5). Contributions of FAS fluency (z = 1.1), Letter-Number Sequencing (z = 1.1), Paired Associates immediate recall (z = 1.3), Digit Span forward (z = 0.5), and Digit Span backward (z = 0.8) were below the reliability threshold.

$PTSD_{past}$ and no-PTSD

Results revealed a significant association among the variables (inertia = 4.5, p, <.001), which was best explained by one latent variable (eigenvalue = 3.95, p < .001) that accounted for 87.4% of the variables' covariance. Among the y-variables, types of internal details categorized as event, place, time, and perceptual details were found to be reliable contributors (salience to standard error ratios: z = 2.7, 3.9, 2.2 and 2.8, respectively). By contrast, thought/emotion details were not found to be reliable contributors (z = 1.3). Among the x-variables, all CAPS-5 subscales were inversely associated with production of internal details. Contributions were reliable for scores on the avoidance (z = -2.0), NACM (z = -2.5) and arousal subscales (z = -2.1). Scores on the intrusion subscale were below the reliability threshold (z = -1.8). Among the Future Time Perspective scales, only future value contributed reliably and positively to the latent variable (z = 2.0). Contributions of future connectedness (z = 1.0), speed (z = 0.5) and future extension (z = 0.4) were not reliable. Among neurocognitive measures, Paired Associates immediate recall (z = 2.2) and delayed recall (z = 2.0) made reliable and positive contributions to the latent variable. Contributions of FAS fluency (z = 1.5), Letter-Number Sequencing (z = 1.6), Digit Span forward (z = 0.3), and Digit Span backward (z = 1.3) were below the reliability threshold.

Author note We have no known conflicts of interest to disclose. This research was supported by grant I01 CX001596 and a Senior Career Scientist Award (to MV) from the Clinical Sciences Research and Development Service, Department of Veterans Affairs. The authors thank Dr. Daniela Palombo for valuable help during study development and Dominoe Jones and Caroline Strang for research assistance. The contents of this manuscript do not represent the views of the U.S. Department of Veterans Affairs or the United States Government.

References

Abdi, H., & Beaton, D. (2023). *Principal component and correspondence analyses using R*. Springer.

Abdi, H., & Williams, L. J. (2013). Partial least squares methods: Partial least squares correlation and partial least square regression. In B. Reisfeld & A. N. Mayeno (Eds.), *Methods in molecular biology* (Vol. 930, pp. 549–570). Humana Press. https://doi.org/10.1007/978-1-62703-059-5_21

Acevedo-Molina, M. C., Novak, A. W., Gregoire, L. M., Mann, L. G., Andrews-Hanna, J. R., & Grilli, M. D. (2020). Emotion matters: The influence of valence on episodic future thinking in young and older adults. *Consciousness and Cognition, 85*, 103023. https://doi.org/10.1016/j.concog.2020.103023

Addis, D. R., & Schacter, D. L. (2008). Constructive episodic simulation: Temporal distance and detail of past and future events modulate hippocampal engagement. *Hippocampus, 18*, 227–237. https://doi.org/10.1002/hipo.20405

Addis, D. R., Wong, A. T., & Schacter, D. L. (2007). Remembering the past and imagining the future: Common and distinct neural substrates during event construction and elaboration. *Neuropsychologia, 45*, 1363–1377. https://doi.org/10.1016/j.neuropsychologia.2006.10.016

Addis, D. R., Wong, A. T., & Schacter, D. L. (2008). Age-related changes in the episodic simulation of future events. *Psychological Science, 19*, 33–41. https://doi.org/10.1111/j.1467-9280.2008.02043.x

Addis, D. A., Hach, S., & Tippett, L. J. (2016). Do strategic processes contribute to the specificity of future simulation in depression? *British Journal of Clinical Psychology, 55*, 167–186. https://doi.org/10.1111/bjc.12103

Akaike, H. (1974). A new look at the statistical model identification. *IEEE Transactions on Automatic Control, 19*, 716–723. https://doi.org/10.1109/TAC.1974.1100705

Andrews-Hanna, J. R., Reidler, J. S., Sepulcre, J., Poulin, R., & Buckner, R. L. (2010). Functional-anatomic fractionation of the brain's default network. *Neuron, 65*, 550–562. https://doi.org/10.1016/j.neuron.2010.02.005

Barsics, C., Van der Linden, M., & D'Argembeau, A. (2016). Frequency, characteristics, and perceived functions of emotional future thinking in daily life. *The Quarterly Journal of Experimental Psychology, 69*, 217–233. https://doi.org/10.1080/17470218.2015.1051560

Bates, D., Maechler, M., Bolker, B., Walker, S., Christensen, R. H., Singmann, H., & Dai, B. (2014). lme4: Linear mixed effects models using Eigen and S4. R package version 1.1-7.

Beaton, D., Rieck, J., Fatt, C. R. C., & Abdi, H. (2013). Two-table ExPosition.

Beck, A. T., Steer, R. A., & Brown, G. K. (1996). *Beck depression inventory-II*. The Psychological Corporation. https://doi.org/10.1037/t00742-000

Benoit, R. G., & Schacter, D. L. (2015). Specifying the core network supporting episodic simulation and episodic memory by activation likelihood estimation. *Neuropsychologia, 75*, 450–457. https://doi.org/10.1016/j.neuropsychologia.2015.06.034

Benoit, R. G., Gilbert, S. J., & Burgess, P. W. (2011). A neural mechanism mediating the impact of episodic prospection on farsighted decisions. *Journal of Neuroscience, 31*, 6771–6779. https://doi.org/10.1523/JNEUROSCI.6559-10.2011

Berntsen, D., & Rubin, D. C. (2006). The centrality of event scale: A measure of integrating a trauma into one's identity and its relation to post-traumatic stress disorder symptoms. *Behaviour Research and Therapy, 44*, 219–231. https://doi.org/10.1016/j.brat.2005.01.009

Brewin, C. R. (2011). The nature and significance of memory disturbance in posttraumatic stress disorder. *Annual Review of Clinical Psychology, 7*, 203–227. https://doi.org/10.1146/annurev-clinpsy-032210-104544

Brown, A. D., Root, J. C., Romano, T. A., Chang, L. J., Bryant, R. A., & Hirst, W. (2013). Overgeneralized autobiographical memory and future thinking in combat veterans with posttraumatic stress disorder. *Journal of Behavior Therapy and Experimental Psychiatry, 44*, 129–134. https://doi.org/10.1016/j.jbtep.2011.11.004

Brown, A. D., Addis, D. A., Romano, T. A., Marmar, C. R., Bryant, R. A., Hirst, W., & Schacter, D. L. (2014). Episodic and semantic components of autobiographical memories and imagined future events in post-traumatic stress disorder. *Memory, 22*, 595–604. https://doi.org/10.1080/09658211.2013.807842

Brown, A. D., Kouri, N. A., Rahman, N., Joscelyne, A., Bryant, R. A., & Marmar, C. R. (2016). Enhancing self-efficacy improves episodic future thinking and social-decision making in combat veterans with posttraumatic stress disorder. *Psychiatry Research, 242*, 19–25. https://doi.org/10.1016/j.psychres.2016.05.026

Bryan, C. J., & Bryan, A. B. O. (2021). Delayed reward discounting and increased risk for suicide attempts among US adults with probable PTSD. *Journal of Anxiety Disorders, 81*, 102414. https://doi.org/10.1016/j.janxdis.2021.102414

Bryant, R. A., & Guthrie, R. M. (2007). Maladaptive self-appraisal before trauma exposure predicts posttraumatic stress disorder. *Journal of Consulting and Clinical Psychology, 75*, 812–815. https://doi.org/10.1037/0022-006X.75.5.812

Bryant, R. A., Sutherland, K., & Guthrie, R. M. (2007). Impaired specific autobiographical memory as a risk factor for posttraumatic stress after trauma. *Journal of Abnormal Psychology, 116*, 837–841. https://doi.org/10.1037/0021-843X.116.4.837

Champely, S. (2020). pwr: Basic functions for power analysis. R package version 1.3-0. https://CRAN.R-project.org/package=pwr

Chessell, Z. J., Rathbone, C. J., Souchay, C., Charlesworth, L., & Moulin, C. J. A. (2014). Autobiographical memory, past and future events, and self-images in younger and older adults. *Self and Identify, 13*, 380–397. https://doi.org/10.1080/15298868.2013.836132

Cohen, J. (1988). *Statistical Power Analysis for the Behavioral Sciences*. Lawrence Erlbaum.

Cole, S. N., & Berntsen, D. (2016). Do future thoughts reflect personal goals? Current concerns and mental time travel into the past and future. *Quarterly Journal of Experimental psychology, 69*, 273–284. https://doi.org/10.1080/17470218.2015.1044

Conway, M. A., & Pleydell-Pearce, C. W. (2000). The construction of autobiographical memories in the self-memory system. *Psychological Review, 107*, 261–288. https://doi.org/10.1037//0033-295X.107.2.261

D'Argembeau, A. (2016). The role of personal goals in future-oriented mental time travel. In K. Michaelian, S. B. Klein, & K. K. Szpunar (Eds.), *Seeing the future: Theoretical perspectives on future-oriented mental time travel* (pp. 199–216). Oxford University Press.

D'Argembeau, A., & Mathy, A. (2011). Tracking the construction of episodic future thoughts. *Journal of Experimental Psychology: General, 140*, 258–271. https://doi.org/10.1037/a0022581

D'Argembeau, A., & Van der Linden, M. (2004). Phenomenal characteristics associated with projecting oneself back into the past and forward into the future: Influence of valence and temporal distance. *Consciousness and Cognition, 13*, 844–858. https://doi.org/10.1016/j.concog.2004.07.007

D'Argembeau, A., & Van der Linden, M. (2012). Predicting the phenomenology of episodic future thoughts. *Consciousness and Cognition, 21*, 1198–1206. https://doi.org/10.1016/j.concog.2012.05.004

D'Argembeau, A., Ortoleva, C., Jumentier, S., & Van der Linden, M. (2010). Component processes underlying future thinking. *Memory and Cognition, 38*, 809–819. https://doi.org/10.3758/MC.38.6.809

D'Argembeau, A., Renaud, O., & Van der Linden, M. (2011). Frequency, characteristics, and functions of future-oriented thoughts in daily life. *Applied Cognitive Psychology, 35*, 96–103. https://doi.org/10.1002/acp.1647

De Vito, S., Neroni, M. A., Gamboz, N., Della Salla, S., & Brandimonte, M. A. (2015). Desirable and undesirable future thoughts call for different scene construction processes. *Quarterly Journal of Experimental Psychology, 68*, 75–82. https://doi.org/10.1080/17470218.2014.937448

De Volder, M., & Lens, W. (1982). Academic achievement and future time perspective as a cognitive motivational concept. *Journal of Personality and Social Psychology, 42*, 566–571. https://doi.org/10.1037//0022-3514.42.3.566

Delis, D. C., Kaplan, E., & Kramer, J. (2001). *Delis-Kaplan executive function system*. The Psychological Corporation.

Desrochers, A. B., Rouleau, I., Angehrn, A., Vasiliadis, H.-M., Saumier, D., & Brunet, A. (2021). Trauma on duty: Cognitive functioning in police officers with and without posttraumatic stress disorder (PTSD). *European Journal of Psychotraumatology, 12*, 1959117. https://doi.org/10.1080/20008198.2021.1959117

Efron, B., & Tibshirani, R. (1986). Bootstrap methods for standard errors, confidence intervals, and other measures of statistical accuracy. *Statistical Science, 1*, 54–77. https://doi.org/10.1214/ss/1177013815

Ehlers, A., & Clark, D. M. (2000). A cognitive model of posttraumatic stress disorder. *Behaviour Research and Therapy, 38*, 319–345. https://doi.org/10.1016/S0005-7967(99)00123-0

Engelbrecht, A., & Jobson, L. (2020). Self-concept, post-traumatic self-appraisals and post-traumatic psychological adjustment: What are the relationships? *Behavioural and Cognitive Psychotherapy, 48*, 463–480. https://doi.org/10.1017/S1352465820000156

First, M. B., Williams, J. B. W., Karg, R. S., & Spitzer, R. L. (2016). *User's guide for the SCID-5-CV Structured Clinical Interview for DSM-5® disorders: Clinical version*. American Psychiatric Publishing.

Fortier, C. B., Amick, M. M., Grande, L., McGlynn, S., Kenna, A., Morra, L., Clark, A., Milberg, W. P., & McGlinchey, R. E. (2014). The Boston Assessment of Traumatic Brain Injury–Lifetime (BAT-L) semistructured interview: Evidence of research utility and validity. *Journal of Head Trauma Rehabilitation, 29*, 89–98. https://doi.org/10.1097/HTR.0000000000000700

Gamble, B., Moreau, D., Tippett, L. J., & Addis, D. R. (2019). Specificity of future thinking in depression: A meta-analysis. *Perspectives on Psychological Science, 14*, 816–834. https://doi.org/10.1177/1745691619851784

Gamble, B., Tippett, L. J., Moreau, D., & Addis, D. R. (2021). The futures we want: How goal-directed imagination relates to mental health. *Clinical Psychological Science, 9*, 732–751. https://doi.org/10.1177/2167702620986096

Hallford, D. J., Austin, D. W., Takano, K., & Raes, F. (2018). Psychopathology and episodic future thinking: A systematic review and meta-analysis of specificity and episodic detail. *Behaviour Research and Therapy, 102*, 42–51. https://doi.org/10.1016/j.brat.2018.01.003

Hallford, D. J., Yeow, J. J. E., Fountas, G., Herrick, C. A., Raes, F., & D'Argembeau, A. (2020). Changing the future: An initial test of Future Specificity Training (FeST). *Behaviour Research and Therapy, 131*, 103638. https://doi.org/10.1016/j.brat.2020.103638

Hallford, D. J., Barry, T. J., Belmans, E., Raes, F., Dax, S., Nishiguchi, Y., & Takano, K. (2021). Specificity and detail in autobiographical memory retrieval: A multi-site (re)investigation. *Memory, 29*, 1–10. https://doi.org/10.1080/09658211.2020.1838548

Halligan, S. L., Michael, T., Clark, D. M., & Ehlers, A. (2003). Posttraumatic stress disorder following assault: The role of cognitive processing, trauma memory, and appraisals. *Journal of Consulting and Clinical Psychology, 71*, 419–431. https://doi.org/10.1037/0022-006X.71.3.419

Harvey, A. G., Bryant, R. A., & Dang, S. T. (1998). Autobiographical memory in acute stress disorder. *Journal of Consulting and Clinical Psychology, 66*, 500–506. https://doi.org/10.1037/0022-006X.66.3.500

Hill, P. F., & Emery, L. J. (2013). Episodic future thought: Contributions from working memory. *Consciousness and Cognition, 22*, 677–683. https://doi.org/10.1016/j.concog.2013.04.002

Husman, J., & Shell, D. F. (2008). Beliefs and perceptions about the future: A measurement of future time perspective. *Learning and Individual Differences, 18*, 166–175. https://doi.org/10.1016/j.lindif.2007.08.001

Jing, H. G., Madore, K. P., & Schacter, D. L. (2016). Worrying about the future: An episodic specificity induction impacts problem solving, reappraisal, and well-being. *Quarterly Journal of Experimental Psychology, 145*, 402–418. https://doi.org/10.1037/xge0000142

Khan, S., & Haque, S. (2022). Autobiographical memory and future episodic thinking among trauma-exposed Rohingya refugee people. *Applied Cognitive Psychology, 36*, 1300–1311. https://doi.org/10.1002/acp.4014

Kleim, B., & Ehlers, A. (2008). Reduced autobiographical memory specificity predicts depression and posttraumatic stress disorder after recent trauma. *Journal of Consulting and Clinical Psychology, 76*, 231–242. https://doi.org/10.1037/0022-006X.76.2.231

Kleim, B., Graham, B., Fihosy, S., Stott, R., & Ehlers, A. (2014). Reduced specificity in episodic future thinking in posttraumatic stress disorder. *Clinical Psychological Science, 2*, 165–173. https://doi.org/10.1177/2167702613495199

Koch, S. B., van Zuiden, M., Nawijn, L., Frijling, J. L., Veltman, D. J., & Olff, M. (2016). Aberrant resting-state brain activity in posttraumatic stress disorder: A meta-analysis and systematic review. *Depression and Anxiety, 33*, 592–605. https://doi.org/10.1002/da.22478

Krishnan, A., Williams, L. J., McIntosh, A. R., & Abdi, H. (2011). Partial least squares (PLS) methods for neuroimaging: A tutorial and review. *NeuroImage, 56*, 455–475. https://doi.org/10.1016/j.neuroimage.2010.07.034

Lalla, A., & Sheldon, S. (2021). The effects of emotional valence and perceived life stress on recalling personal experiences and envisioning future events. *Emotion, 21*, 1392–1401. https://doi.org/10.1037/emo0001050

Lapidow, E. S., & Brown, A. D. (2015). Autobiographical memories and PTSD. In R. C. Marin, R. V. Preedy, & B. V. Patel (Eds.), *Comprehensive guide to post-traumatic stress disorder*. Springer International Publishing.

Levine, B., Svoboda, E., Hay, J. F., Winocur, G., & Moscovitch, M. (2002). Aging and autobiographical memory: Dissociating episodic from semantic retrieval. *Psychology and Aging, 17*, 677–689. https://doi.org/10.1037//0882-7974.17.4.677

MacLeod, A. K., & Conway, C. (2007). Well-being and positive future thinking for the self versus others. *Cognition and Emotion, 21*, 1114–1124. https://doi.org/10.1080/02699930601109507

Madori, K. P., Gaesser, B., & Schacter, D. L. (2014). Constructive episodic simulation: Dissociable effects of a specificity induction on remembering, imagining, and describing in young and older adults. *Journal of Experimental Psychology: Learning, Memory and Cognition, 40*, 609–622. https://doi.org/10.1037/a0034885

Mather, M., & Sutherland, M. R. (2011). Arousal-biased competition in perception and memory. *Perspectives on Psychological Science, 6*, 114–133. https://doi.org/10.1177/1745691611400234

Memel, M., Lynch, K., Lafleche, G., & Verfaellie, M. (2021). Autobiographical recall of a stressful negative event in veterans with PTSD. *Memory, 29*, 719–728. https://doi.org/10.1080/09658211.2021.1940204

Miller, G. A., & Chapman, J. P. (2001). Misunderstanding analysis of covariance. *Journal of Abnormal Psychology, 110*, 40–48. https://doi.org/10.1037//0021-843X.110.1.40

Miller, M. M., Wolf, E. J., Kilpatrick, D., Resnick, H., Marx, B. P., Holowka, D. W., Keane, T. M., Rosen, R. C., & Friedman, M. J. (2013). The prevalence and latent structure of proposed DSM-5 posttraumatic stress disorder symptoms in U.S. national and veteran samples. *Psychological Trauma: Theory, Practice, and Policy, 5*, 501–512. https://doi.org/10.1037/a0029730

Miller, D. R., Hayes, S. M., Hayes, J. P., Spielberg, J. M., Lafleche, G., & Verfaellie, M. (2017). Default mode network subsystems are differentially disrupted in posttraumatic stress disorder. *Biological Psychiatry: Cognitive Neuroscience and Neuroimaging, 2*, 363–371. https://doi.org/10.1016/j.bpsc.2016.12.006

Miloyan, B., Bulley, A., & Suddendorf, T. (2016). Episodic foresight and anxiety: Proximate and ultimate perspectives. *British Journal of Clinical Psychology, 55*, 4–22. https://doi.org/10.1111/bjc.12080

Moore, S. A., & Zoellner, L. A. (2007). Overgeneral autobiographical memory and traumatic events: An evaluative review. *Psychological Bulletin, 133*, 419–437. https://doi.org/10.1037/0033-2909.133.3.419

Moscovitch, M. (1992). Memory and working-with-memory: A component process model based on modules and central systems. *Journal of Cognitive Neuroscience, 4*, 257–267. https://doi.org/10.1162/jocn.1992.4.3.257

Mullaly, S. L., & Maguire, E. A. (2014). Memory, imagination, and predicting the future: A common brain mechanism? *The Neuroscientist, 20*, 220–234. https://doi.org/10.1177/1073858413495091

Nakagawa, S., & Schielzeth, H. (2013). A general and simple method for obtaining R^2 from generalized linear mixed-effects models. *Methods in Ecology and Evolution, 4*, 133–142. https://doi.org/10.1111/j.2041-210x.2012.00261.x

Ono, M., & Devilly, G. J. (2016). A meta-analytic review of overgeneral memory: The role of trauma history, mood, and the presence of posttraumatic stress disorder. *Psychological Trauma: Theory, Practice, and Policy, 8*, 157–164. https://doi.org/10.1037/tra0000027

Peters, J., & Buchel, C. (2010). Episodic future thinking reduces reward delay discounting through an enhancement of prefrontal-mediotemporal interactions. *Neuron, 66*, 138–148. https://doi.org/10.1016/j.neuron.2010.03.026

Petzold, M., & Bunzeck, N. (2022). Impaired episodic memory in PTSD patients – A meta-analysis of 47 studies. *Frontiers in Psychiatry, 13*, 909442. https://doi.org/10.3389/fpsyt.2022.909442

Polak, A. R., Witteveen, A. B., Reitsma, J. B., & Olff, M. (2012). The role of executive function in posttraumatic stress disorder: A systematic review. *Journal of Affective Disorders, 141*, 11–21. https://doi.org/10.1016/j.jad.2012.01.001

Puig, V. A., & Szpunar, K. K. (2017). The devil is in the details: Comparisons of episodic simulations of positive and negative future events. *Emotion, 17*, 867. https://doi.org/10.1037/emo0000294

R Core Team (2019). R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. https://www.R-project.org/

Race, E., Keane, M. M., & Verfaellie, M. (2011). Medial temporal lobe damage causes deficits in episodic memory and episodic future thinking not attributable to deficits in narrative construction. *Journal of Neuroscience, 31*, 10262–10269. https://doi.org/10.1523/JNEUROSCI.1145-11.2011

Robinson, S. R., & Jobson, L. A. (2013). The relationship between post-traumatic stress disorder symptoms and overgeneral autobiographical memory in older adults. *Clinical Psychologist, 17*, 26–30. https://doi.org/10.1111/cp.12000

Rubin, D. C., Berntsen, D., & Bohni, M. K. (2008). A memory based model of posttraumatic stress disorder: Evaluating basic assumptions underlying the PTSD diagnosis. *Psychological Review, 115*, 985–1011. https://doi.org/10.1037/a0013397

Sayed, S., Iacovielo, B. M., & Charney, D. S. (2015). Risk factors for the development of psychopathology following trauma. *Current Psychiatry Reports, 17*, 70. https://doi.org/10.1007/s11920-015-0612-y

Schacter, D. L., & Addis, D. R. (2007). The cognitive neuroscience of constructive memory: Remembering the past and imagining the future. *Philosophical Transactions of the Royal Society B: Biological Sciences, 362*, 773–786. https://doi.org/10.1098/rstb.2007.2087

Schacter, D. L., & Addis, D. R. (2009). On the nature of medial temporal lobe contributions to the constructive simulation of future events. *Philosophical Transactions of the Royal Society B: Biological Sciences, 364*, 1245–1253. https://doi.org/10.1098/rstb.2008.0308

Schacter, D. L., Addis, D. R., & Buckner, R. L. (2008). Episodic simulation of future events: Concepts, data and applications. *Annals of the New York Academy of Sciences, 1124*, 39–60. https://doi.org/10.1196/annals.1440.001

Schacter, D. L., Benoit, R. G., & Szpunar, K. K. (2017). Episodic future thinking: Mechanisms and functions. *Current Opinion in*

Behavioral Sciences, 17, 41–50. https://doi.org/10.1016/j.cobeha.2017.06.002
Schienle, A., Wabnegger, A., Schoengassner, F., & Scharmuller, W. (2014). Neuronal correlates of three attentional strategies during affective picture processing: An fMRI study. *Cognitive, Affective and Behavioral Neuroscience, 14*, 1320–1326. https://doi.org/10.3758/s13415-014-0274-y
Schonfeld, S., Ehlers, A., Bollinghaus, I., & Reif, W. (2007). Overgeneral memory and suppression of trauma memories in posttraumatic stress disorder. *Memory, 15*, 339–352. https://doi.org/10.1080/09658210701256571
Schwarz, G. (1978). Estimating the dimension of a model. *Annals of Statistics, 6*, 461–464. https://doi.org/10.1214/aos/1176344136
Schweizer, S., & Dalgeish, T. (2016). The impact of affective contexts on working memory capacity in healthy populations and in individuals with PTSD. *Emotion, 16*, 16–23. https://doi.org/10.1037/emo0000072
Schweizer, S., & Dalgleish, T. (2011). Emotional working memory capacity in posttraumatic stress disorder (PTSD). *Behaviour Research and Therapy, 49*, 498–504. https://doi.org/10.1016/j.brat.2011.05.007
Scott, J. C., Matt, G. E., Wrocklage, K. M., Crnich, C., Jordan, J., Southwick, S. M., Krystal, J. H., & Schweinsburg, B. C. (2015). A quantitative meta-analysis of neurocognitive functioning in posttraumatic stress disorder. *Psychological Bulletin, 141*, 105–140. https://doi.org/10.1037/a0038039
Seligowski, A. V., Rogers, A. P., & Orcutt, H. K. (2016). Relations among emotion regulation and DSM-5 symptom clusters of PTSD. *Personality and Individual Differences, 92*, 104–108. https://doi.org/10.1016/j.paid.2015.12.032
Shandera-Ochsner, A. L., Berry, D. T. R., Harp, J. P., Edmundson, M., Graue, L. O., Roach, A., & High, W. M. (2013). Neuropsychological effects of self-reported deployment-related MTBI and current PTSD in OIF/OEF Veterans. *The Clinical Neuropsychologist, 27*, 881–907. https://doi.org/10.1080/13854046.2013.802017
St. Jacques, P. L., Kragel, P. A., & Rubin, D. C. (2013). Neural networks supporting autobiographical memory retrieval in posttraumatic stress disorder. *Cognitive, Affective and Behavioral Neuroscience, 13*, 554–566. https://doi.org/10.3758/s13415-013-0157-7
Sumner, J. A. (2012). The mechanisms underlying overgeneral autobiographical memory: An evaluative review of evidence for the CaR-FA-X model. *Clinical Psychology Review, 32*, 34–48. https://doi.org/10.1016/j.cpr.2011.10.003
Sutherland, K., & Bryant, R. A. (2005). Self-defining memories in post-traumatic stress disorder. *British Journal of Clinical Psychology, 44*, 591–598. https://doi.org/10.1348/014466505X64081
Sutherland, K., & Bryant, R. A. (2007). Autobiographical memory in posttraumatic stress disorder before and after treatment. *Behaviour Research and Therapy, 445*, 2915–2923. https://doi.org/10.1016/j.brat.2007.08.009
Szpunar, K. K. (2010). Episodic future thought. *Perspectives on Psychological Science, 5*, 142–162. https://doi.org/10.1177/1745691610362350
Szpunar, K. K., Addis, D. R., & Schacter, D. L. (2012). Memory for emotional simulations: Remembering a rosy future. *Psychological Science, 23*, 24–29. https://doi.org/10.1177/0956797611422237
Trope, Y., & Liberman, N. (2010). Construal-level theory of psychological distance. *Psychological Review, 117*, 440–463. https://doi.org/10.1037/a0018963
Wardell, V., Grilli, M. D., & Palombo, D. J. (2022). Simulating the best and worst of times: The powers and perils of emotional simulation. *Memory, 30*, 1212–1225. https://doi.org/10.1080/09658211.2022.2088796
Weathers, F. W., Blake, D. D., Schnurr, P. P., Kaloupek, D. G., Marx, B. P., & Keane, T. M. (2013). The Life Events Checklist for DSM-5 (LEC-5). Instrument available from the National Center for PTSD at www.ptsd.va.gov
Weathers, F. W., Bovin, M. J., Lee, D. J., Sloan, D. M., Schnurr, P. P., Kaloupek, D., Keane, T. M., & Marx, B. P. (2018). The Clinician-Administered PTSD Scale for DSM–5 (CAPS-5): Development and initial psychometric evaluation in military veterans. *Psychological Assessment, 30*, 383–395. https://doi.org/10.1037/pas0000486
Wechsler, D. (2008). *Wechsler Adult Intelligence Scale – Fourth Edition*. Pearson Assessment.
Wechsler, D. (2009). *Wechsler Memory Scale – Fourth Edition (WMS-IV)*. Pearson Assessment.
Williams, J. M. G., Barnhofer, T., Crane, C., Hermans, D., Raes, F., Watkins, E., & Dalgleish, T. (2007). Autobiographical memory specificity and emotional disorder. *Psychological Bulletin, 133*, 122–148. https://doi.org/10.1037/0033-2909.133.1.122
Woon, F. L., Farrer, T. J., Braman, C. R., Mabey, J. K., & Sawson, W. H. (2017). A meta-analysis of the relationship between symptom severity of Posttraumatic Stress Disorder and executive function. *Cognitive Neuropsychiatry, 22*, 1–16. https://doi.org/10.1080/13546805.2016.1255603

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Open practices The experiment was not preregistered. Data can be obtained from the authors upon request.