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Changes in Trauma Memory and Patterns of Posttraumatic Stress

Sharon Dekel
Tel-Aviv University

George A. Bonanno
Columbia University

The traditional static view of trauma memory holds that memories for such events are fixed and relatively unchanging over time. A more recent dynamic view proposes that memory for potential trauma, like memory for ordinary events, changes with time. The present study examined predictions from these competing theories in repeated assessments of high exposed survivors of the September 11th (9/11) attacks. Memory was assessed using both standardized questionnaires and a free recall paradigm. These data and a measure of posttraumatic stress were obtained at 7 and 18 months post-9/11. Results showed that survivors' recollections of 9/11 varied between assessment points and were moderated by their trajectory of posttraumatic stress. Individuals who were either resilient or recovered over time created a more benign memory of the event over time, whereas individuals who experienced chronic posttraumatic stress had relatively unchanging memories.

Keywords: trauma, memory, narrative, PTSD, resilience, terrorism

Most people are exposed to potentially traumatic events (PTEs) at some point in their lives. How people remember these experiences and how such memories influence well-being has been hotly debated. Traditionally, memories for PTEs were believed to be fixed and inflexible; the arousing nature of the event was thought to create long-lasting memories that are relatively immune to change over time. In recent years, this so-called static notion of trauma memory has been seriously challenged. A growing number of empirical studies seem to suggest that memories of PTEs may not be as fixed as had been previously thought. Rather, despite their extraordinary nature, people's memories of PTEs appear to be susceptible to distortion and fabrication over time (see Brewin, 2007, for a review). Of particular significance are recent studies that show an association between changes in trauma recollection and the mental health of an individual after the event. Specifically, these studies suggest that individuals with posttraumatic stress disorder (PTSD) remember more trauma over time (e.g., King et al., 2000; Koenen, Stellman, Dohrenwend, Sommer, & Stellman, 2007).

Although the notion that trauma memory is "dynamic" has gained currency, the supportive empirical evidence is still limited in nature and scope. The current study attempts to address this deficit. Specifically, we studied highly exposed survivors of the September 11th (9/11) terrorist attacks to determine whether change in recollections of the event were related to the trajectory of their posttraumatic stress (PTS). We included both standardized memory questionnaires and open-ended narrative interviews about the event. It allowed us to examine (1) possible changes in the length, language, and content of trauma memories over time and (2) possible links between the memory change and the course of trauma outcome.

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Sharon Dekel, Bob Shapell School of Social Work, Tel-Aviv University, Tel-Aviv, Israel. George A. Bonanno, Department of Counseling and Clinical Psychology, Teachers College, Columbia University.

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Correspondence concerning this article should be addressed to Sharon Dekel, Bob Shapell School of Social Work, Tel-Aviv University, Tel-Aviv, 69978, Israel. E-mail: dekel.sharon@gmail.com

Competing Views on Trauma Memory

Janet (1889) proposed that trauma memory is special because the highly threatening nature of the traumatic experience cannot be assimilated into a person's meaning and belief system. Traumatic memory thus follows a dissociative process, whereby the traumatic event is split-off from the ongoing stream of conscious experience and stored as an "idée fixe." In turn, the memory for the event may be less accessible to conscious recollection but upon involuntary retrieval appears as a permanent and unchangeable mental representation (Janet, 1889, 1904). James (1890) had similarly argued that trauma memory is static, suggesting that highly arousing memories "leave a scar upon the cerebral tissues" (p. 670).

Although contemporary clinical theorists have tended to endorse the static view of trauma memory (e.g., Hermann, 1992; van der Kolk & Fisler, 1995), supportive empirical evidence is largely indirect. Research on flashbulb memories for dramatic public events (e.g., the Kennedy assassination), for example, suggest that such memories are durable and unchanging (e.g., R. Brown & Kulik, 1977; Talarico & Rubin, 2003). A related line of laboratory studies have shown that emotion enhances memory and that memory of the central aspects of negatively arousing events is particularly well retained (e.g., Cahill & McGaugh, 1995; Heuer & Reisberg, 1990).

Recently, the competing idea that traumatic memories are not extraordinary but rather governed by the same mechanisms as other memory phenomenon has gained currency. An abundance of empirical evidence indicates that ordinary memory is not static but is rather dynamic and subject to change (Baddeley, 1990). As Barlett (1932) long ago observed, "though we may still talk of [memory] traces, there is no reason of regarding them as made

complete, stored up somewhere and then reexcited at some much later moment" (p. 211). Rather, memories are continually reconstructed in accord with previous knowledge and experiences, attitudes, belief systems, and the conditions and context at the time of recall. Moreover, memories are vulnerable to interference and distortion at each retrieval episode (Nader & Hardt, 2009; Nader, Schafe, & LeDoux, 2000). Therefore, increasingly, the stored memory will tend to diverge from the original memory.

More direct evidence for the dynamic view of trauma memory comes from several lines of research. Research using eyewitness testimony paradigm for example has shown that subjects who had viewed video footage of a shocking event (automobile accident, robbery, etc.) and provided with misleading information about the content tend to incorporate the misleading information into their memories of the event (e.g., Loftus, 1979, 1996, 2005). An independent but compatible line of research, using the reality monitoring paradigm, has repeatedly shown that in a laboratory setting, subjects fail to discriminate between memories produced by external events (i.e., perception) and those produced by internal events (i.e., thoughts, imagination etc.). In other words, subjects come to believe that what they imagined had actually happened and that they witnessed it in reality (e.g., Johnson & Raye, 1981, 1998; Johnson, Raye, Wang, & Taylor, 1979).

A serious limitation of the laboratory cited either in support or in opposition to a particular view of trauma memory is that it fails to capture the potentially horrifying nature of real-life PTEs (Brown, Scheflin, & Hammond, 1998). For this reason, a growing number of studies have applied the alternative approach of examining recollections pertaining to actual PTEs. Although this approach sacrifices experimental control, it adds a higher level of ecological validity. As we discuss below, this research appears to support the dynamic view that memories for traumatic events are malleable and can change over time (see van Giezen, Arensman, Spinhoven, & Wolters, 2005, for a review).

Longitudinal Studies of Trauma Recollections

Naturalistic studies of memory recollections in directly exposed survivors of PTEs have used both standardized questionnaire measures and free recall or open-ended accounts. Studies using standardized questionnaires have consistently shown that trauma memory changes over time. For example, studies of military veterans show prominent increases in memory for combat-related PTEs over time. A crucial moderating factor in these effects, however, is level of PTSD at time of recall. Individuals experiencing elevated PTSD symptoms tend to recall increasingly greater trauma exposure over time (e.g., Dekel, Ein-Dor, & Solomon, submitted; King et al., 2000; Engelhard, van den Hout, & McNally, 2008; Southwick Morgan, Nicolaou, & Charney, 1997). A potentially crucial limitation of this evidence, however, is that the observed memory bias may have been caused in part by the standardized nature of the questions (e.g., L. R. Shapiro, Blackford, & Chen, 2005). Standardized questions narrow cognitive set, encourage the responder to volunteer uncertain information (Lipton, 1977), may provide misleading information (e.g., Farrar & Goodman, 1992), and may inadvertently increase inaccuracies in reporting (e.g., Zaragoza & Mitchell, 1996).

By contrast, the use of open-ended free recall allows trauma reporting to emerge freely over time by eliciting the participants' own "story" of the event, including thoughts, actions, feelings, and impressions during the event, as they are organized subjectively. Unfortunately, in comparison with standardized methods, relatively little is known about how trauma narratives change over time or how that change might relate to PTSD symptoms (see O'Kearney & Perrott, 2006, for a review). Narrative memory studies have often pertained to stressful events broadly defined (Pennebaker, 1993; Pennebaker & Francis, 1996) or examined trauma memory in the context of other events, such as ongoing psychotherapy (Foa, Molnar, & Cashman, 1995; van Minnen, Wessel, Dijkstra, & Roelofs, 2002). Trauma narrative studies have also tended to focus primarily on changes in narrative *structure* rather than content (e.g., Foa et al., 1995; Halligan, Michael, Clark, & Ehlers, 2003; Jones, Harvey, & Brewin, 2007), whereas potentially important narrative components such as length, language, and content have far received relatively little empirical scrutiny. In studies that have documented changes in these narrative components, the directionality of the changes and the relation to PTSD has been inconclusive (e.g., Holmes et al., 2007; Jones et al., 2007; Pennebaker, Mayne, & Francis, 1997).

The Current Investigation

To address these issues in the current investigation, we used both standardized questionnaires and a narrative free-recall approach to assess trauma recollections at two time points, 7 and 18 months after the 9/11 attacks. We assessed both subjective (e.g., perceived danger) and more objective (e.g., witnessing death or injury to others) aspects of potential trauma exposure. In analyzing the free-recall data, we focused on the content, language, and length of the narratives and examined aspects of language previously shown to increase after a life-threatening event: words indicating negative feelings, causation and insight, death, and psychological detachment (Cohn, Mehl, & Pennebaker, 2004). Finally, we compared the various indices of change in trauma recollection with longitudinal patterns of PTS, specifically to the "chronic" and "resilient-recovered" symptom trajectories (Bonanno, 2004).

Following cognitive models of trauma (Brewin & Holmes, 2003), we expected that trauma recollections would change over time. Specifically, we anticipated that participants categorized as resilient-recovered would show reduced memory for trauma exposure over time and that this change would be especially apparent in narrative accounts of the event. In accord, we also expected that their personal narratives would decrease in both trauma-related expressions (i.e., death words, negative emotions) and length. By contrast, we anticipated that participants with chronic PTS symptoms, because of the prolonged nature of their symptoms, would show little or no change in either the details or the form of their recollections of the trauma.

Method

Participants and Procedures

As described elsewhere (Bonanno, Rennicke, & Dekel, 2005), recruitment for this study targeted high-exposure survivors who had been in or within several blocks of one of the World Trade Center (WTC) towers at the time of the 9/11 attacks. To enlist

these individuals, we contacted companies that had been located in the WTC; posted flyers in downtown Manhattan; and made public announcements on local radio stations. Data were collected 7 months (T1) and 18 months (T2) after 9/11, including a set of questionnaires completed at home and an in-person narrative interview. Participants were paid $100 upon completion of assessments in each time period.

T1 involved 69 participants. Eleven participants could not be located or declined participation at T2. In addition, data from five participants was not used because it was incomplete. The final sample consisted of 49 individuals. Interview data were available at both time points for 39 participants. However, nine interviews had poor audio quality and could not be used. There were no statistically significant demographic differences for participants whose data were included or not included in this study. Participants in the final samples were between the ages of 23 and 59 ($M = 39$ years, $SD = 11$), had an average annual pre-9/11 income of $71,000 ($SD = $51,000), were primarily female (60%) and White (80%), and resided primarily in Manhattan (41%) and Brooklyn (22%). When the first plane struck the WTC, 27% were in one of the two WTC towers, 38% were within 4 blocks of the WTC, and 35% were further than 4 blocks away.

Posttraumatic Stress

PTS was measured using the PTSD Symptom Scale-Self Report version (PSS-SR) (Foa, Riggs, Dancu, & Rothbaum, 1993). The measure is composed of 17 items reflecting the symptoms of PTSD listed in the *DSM–III–R* (American Psychiatric Association, 1987). Participants were asked to rate the frequency with which they experienced each item in the past month using a 3-point Likert scale ranging from "not at all" to "five or more times per week/almost always." The scale has shown good internal consistency and test-retest reliability in past studies (Foa et al., 1993) and in the current investigation ($\alpha = .91$, test-retest $r = .78$).

To examine the long-term course of PTS, we created symptom trajectories using an approach developed in previous research (Bonanno et al., 2005). Participants were categorized as having high or low PTS at each assessment using a cutoff score of 14 that has proven reliable as a screen for PTSD using the PSS-SR (Coffey, Gudmundsdottir, Beck, Palyo, & Miller, 2006). Participants were assigned to a *chronic* group (40%) if they had elevated levels of PTS at both waves of assessment (i.e., above cutoff scores at both assessments). The remainder of the sample was assigned to the *resilient-recovered* group (60%).

Standardized Trauma Memory Questionnaire

Memory for exposure to the 9/11 attacks was assessed at both T1 and T2 using a set of 12 standardized questions (see Table 1). Following the *DSM–IV–TR* (American Psychiatric Association, 2000) criteria for a PTE, two dimensions of exposure were measured. *Objective exposure* questions asked participants to report on a scale ranging from 0 (no) to 3 (yes, many people) whether they witnessed dead bodies, seriously injured people, and people who were killed or jumped from the burning towers as a result of the attacks. *Subjective exposure* questions asked participants about perceived physical danger and emotional distress during the event using a 3-point Likert scale ranging from "not at all" to "very much."

Trauma Narrative Interview

Participants recalled their experience during and after the September 11th attacks at both T1 and T2 in a 30-min open-ended narrative session in response to the following instruction: "I would like you to speak for 30 min about what you went through on September 11 and afterward; your experiences and thoughts and feelings on that day and on the days since September 11." Participants were instructed to focus on their personal experience, to report as openly as possible virtually anything that came to mind, and were minimally interrupted by the interviewer. Interviews were audio-taped and transcribed.

Following previous research, we aimed to target the portion of participants' recollections that pertained to the trauma narrative (i.e., the segment of the report pertaining to actual potential

Table 1
Items in Questionnaire Measuring Subjective and Objective Trauma Exposure

	Questionnaire items
	Subjective exposure[a]
1	Did you feel that you were in immediate physical danger after the first plane struck?
2	Were you highly distressed or fearful after the first plane struck?
3	Did you feel that you were in immediate physical danger after the second plane struck?
4	Were you highly distressed or fearful after the second plane struck?
5	Did you feel that you were in immediate physical danger when the towers began to collapse?
6	Were you highly distressed or fearful when the towers began to collapse?
7	Did you feel that you were in immediate physical danger in the hours after the towers had collapsed?
8	Were you highly distressed or fearful in the hours after the towers had collapsed?
	Objective exposure[b]
1	Did you see people who were seriously injured as a result of the attack?
2	Did you see dead bodies that resulted from the attack?
3	Did you see people killed during the attack?
4	Did you see people jump from the burning towers?

[a] Subjective exposure measured on a 5-point Likert scale ranging from 0 (not at all) to 4 (very much). [b] Objective exposure measured on a scale ranging from 0 (no) to 3 (yes, many people).

trauma) (Foa et al., 1995; Halligan et al., 2003; Harvey & Bryant, 1999; Jones et al., 2007). To this end, we marked the onset of the trauma narrative as when the participant first described the awareness that events of September 11th were unusual and out of the ordinary. The offset of the trauma narrative was marked as the first expression in which the participant indicated leaving the vicinity of the WTC site and that he or she was no longer in immediate danger. Only these sections were coded for the variables listed below.

Content Units (CUs) were measured as the smallest units that conveyed meaningful information, usually pertaining to a thought, feeling, action, description, or detail. This measure is similar to the information units reported in previous trauma narrative studies (Bauer & Bonanno, 2001; Capps & Bonanno, 2000; Foa et al., 1995). Each narrative was parsed into CUs independently by two psychology graduate students. Rater agreement was calculated by dividing the number of agreed-upon units by the number of total units. Mean percentage of initial agreement was 91. Disputed CUs were resolved by consensus. Consistency in a CU between T1 and T2 was defined as the content of a CU containing the same information at each time point. All other units were categorized as "nonconsistent units." Narratives from T1 and T2 from each participant were coded for consistency by two masters-level psychology students independently. Rater agreement was derived in the same manner as for CUs and was again high (.92). Disputed codes were resolved by consensus.

Linguistic categories. Calculation of both overall word count and frequency of specific categories of words was achieved using Linguistic Inquiry and Word Count (LIWC) software (Pennebaker, Francis, & Booth, 2001). LIWC uses an external dictionary composed of over 200 words to categorize written text along various language dimensions. Each word in the written text was evaluated against the dictionary and then assigned to one or more language categories. The program's output included percentage scores for each language category for each narrative (i.e., the total number of words in the text that refer to a certain language dimension divided by the total number of words in the text). For the current investigation, we used the LIWC program to assess *cognitions* (i.e., words suggestive of causal and reflective thinking), *emotions* (i.e., words indicating negative emotions), *death* (i.e., words pertaining to death and dying), and *psychological detachment* (i.e., a composite variable of the number of articles, prepositions, words of more than 6 letters, and an inverse number of first-person singular pronouns in the text).

Results

Standardized Trauma Memory Questionnaire

Table 2 lists means for memory of subjective (e.g., emotional distress) and the objective (e.g., witnessing dead bodies) trauma exposure variables and their correlation with posttraumatic symptoms at 7 and 18 months. Memory of both aspects of trauma exposure was highly correlated across time. However, the correlations were not perfect, suggesting that, as expected, there is some inconsistency in reporting. To examine the change, we summed the total number of discrepant items from the T1 and T2 reports. The frequency distribution of memory change for subjective and objective exposure is presented in Table 3. As anticipated, the majority of the sample (86%) changed their reports of subjective exposure on at least one third of the items between T1 and T2 ($M = 4$, $SD = 1.87$). Memory change was less pronounced for objective trauma exposure. More than half the sample reported identical objective exposure (i.e., witnessing) at T1 and T2 ($M = 0.92$, $SD = 1.24$).

To examine the *directionality of the memory change,* we created two additional variables, one representing amplification of memory and one representing decline in memory. As expected, memory decrease for subjective aspects of trauma exposure was significantly more common ($M = 2.47$; $SD = 2.3$) than amplification ($M = 1.53$, $SD = 1.66$), $t(48) = 1.85$, $p < .05$. The mean total decrease in subjective exposure reports from T1 to T2 was also significant, $t(48) = 1.68$, $p < .05$. Fourteen percent of the decrease in subjective trauma memory could be described as extreme. For example, some subjects endorsed an item at T1 but failed to endorse it at T2. In contrast to memory for subjective trauma, the directionality of change in memory for objective trauma exposure was not significant (decrease change: $M = 0.41$, $SD = 0.79$; increase change: $M = 0.51$, $SD = 1.02$), $t(48) = -0.53$, ns.

Change in Standardized Trauma Memory and Posttraumatic Symptoms

Next, we compared changes in memory for trauma exposure using standardized questionnaires in relation to the PTS trajectories (see Table 4). Participants who exhibited a resilient-recovered trajectory over time also had significantly greater change in their memories for the subjective aspects of trauma exposure compared with participants exhibiting chronically elevated PTS symptoms. Analyses of the direction of change indicated that resilient-

Table 2
Correlations for Subjective and Objective Trauma Exposure and PTS Reported at T1 and T2

Measure	*M*	*SD*	1	2	3	4	5	6
1. Subjective exposure, T1	21.0	7.3	—					
2. Subjective exposure, T2	19.5	7.1	0.69***	—				
3. Objective exposure, T1	3.2	3.4	0.06	0.05	—			
4. Objective exposure, T2	3.4	3.8	0.14	0.19	0.71***	—		
5. PTS symptoms, T1	16.7	10.7	0.44**	0.52***	0.27	0.39**	—	
6. PTS symptoms, T2	14.3	10.5	0.48***	0.63***	0.19	0.31*	0.78***	—

Note. $N = 49$. PTS = posttraumatic stress; T1 and T2 = 7 and 18 months after the attacks. Pearson correlations are computed as case-wise relationships.
* $p < .05$. ** $p < .01$. *** $p < .001$.

Table 3
Frequency Distribution of Number of Changes in Subjective and Objective Trauma Exposure Reported at T1 and T2

	Any change		Increase change		Decrease change		None to endorsement change		Endorsement to none change	
Number of changes	*N*	%	*N*	%	*N*	%	*N*	%	*N*	%
				Subjective exposure reports						
0	3	6.1	21	42.9	14	28.6	35	71.4	37	75.5
1	3	6.1	4	8.2	8	16.3	8	16.3	10	20.4
2	1	2.0	10	20.4	4	8.2	6	12.3	1	2.0
3	12	24.5	10	20.4	8	16.3	0	0.0	0	0.0
4	10	20.4	1	2.0	3	6.1	0	0.0	0	0.0
5	10	20.4	1	2.0	7	14.3	0	0.0	1	2.0
6	6	12.2	2	4.1	2	4.1	0	0.0	0	0.0
7	3	6.1	0	0.0	2	4.1	0	0.0	0	0.0
8	1	2.0	0	0.0	1	2.1	0	0.0	0	0.0
				Objective exposure reports						
0	26	53.1	36	73.5	36	73.5	38	77.6	39	79.6
1	11	22.5	6	12.3	8	16.3	7	14.3	8	16.3
2	5	10.2	4	8.2	3	6.1	2	4.1	1	2.0
3	4	8.2	1	2.0	2	4.1	2	4.1	1	2.0
4	3	6.1	2	4.1	0	0.0	0	0.0	0	0.0

Note. $N = 49$. The changes represent the number of responses changed between measurements. T1 and T2 = 7 and 18 months after the attacks.

recovered participants remembered significantly less subjective trauma exposure over time and had significantly greater than chance change from endorsing a particular subjective exposure item to not endorsing the item (endorsement to none change) than participants with chronic PTS.

By contrast, chronic PTS participants had significantly greater change in their memories for the objective aspects of trauma exposure than the resilient-recovered group. However, there were no meaningful group differences in the direction of change, suggesting that for participants with chronically elevated PTS, the change in objective exposure reflected confusion about the original stressor event rather than a systematic recall bias.

Change in Narrative Trauma Memory Content and Posttraumatic Symptoms

Total word counts in the trauma narratives were highly correlated at T1 and T2, $r = .84$. Trauma narrative word count was also

Table 4
Differences Between PTS Groups in Number of Changes in Subjective and Objective Trauma Exposure Reported at T1 and T2

	Chronic ($n = 21$)		Resilient-recovered ($n = 28$)		
Measure	*M*	*SD*	*M*	*SD*	*t*(47)
		Subjective exposure			
Changes					
Any	3.4	2.2	4.5	1.5	2.07*
Decrease	1.8	2.3	3.0	2.2	1.91*[a]
Increase	1.6	1.7	1.5	1.6	0.32
Endorsement to none	0.1	0.2	0.6	1.0	2.28*
		Objective exposure			
Changes					
Any	1.3	1.4	0.6	1.0	2.10*
Decrease	0.6	1.0	0.3	0.5	1.65
Increase	0.7	0.4	0.4	0.9	1.22
PTS symptoms, T1	25.2	7.9	10.4	7.6	6.63***
PTS symptoms, T2	23.0	8.3	7.0	4.4	9.23***

Note. Number of changes indicates the number of responses changed between measurements. PTS = posttraumatic stress; T1 and T2 = 7 and 18 months after the attacks.
[a] Group difference is significant at one-tail.
* $p < .05$. *** $p < .001$.

moderately correlated with the posttraumatic symptoms at T1 (r = .32) and T2 (r = .28). A 2 (PTS Group) × 2 (Time) repeated measures analysis of variance (ANOVA) for mean word count indicated a significant time effect. Participants generated shorter narrative accounts of the trauma over time (T1: M = 1876, SD = 194.66, T2: M = 1476, SD = 180.1), $F(1, 27) = 13.9$, $p < .001$. However, neither the group effect nor the group × time interaction was significant.

To examine changes in the overall consistency of the narratives, as captured in CUs (see Methods), we calculated proportion scores by dividing the number of consistent CUs by the total number of CUs in the T2 narrative. Across all participants, only a third of the content of the narrative remained the same over time (percentage of consistent units: M = 34.45, SD = 13.3). Interestingly, however, the percentage of consistent units did not differ significantly across the chronic and resilient-recovered groups (chronic: M = 32.3, SD = 15.09; resilient-recovered: M = 35.77, SD = 12.36), $t(27) = -0.67$, ns. Taken as a whole, these results indicate that although trauma narratives evidenced global change in length and factual details over time, the overall quantity of change was not associated with trajectories of posttraumatic symptoms.

Change in Narrative Trauma Memory Language and Posttraumatic Symptoms

We hypothesized that even though trauma narratives may convey similar details (content), the language used to convey that content may nonetheless vary over time with changes in PTS. We first examined language use for the entire trauma narrative. Table 5 presents intercorrelations for language categories and posttraumatic symptoms. As anticipated, a series of repeated measures ANOVAs for the linguistic categories revealed little overall change. The only significant effect was a group effect for death-related words. The chronic PTS group used more death-related words when remembering their 9/11 experiences than those in the resilient-recovered group.

Next, we examined language use only for consistent CUs (i.e., CUs that conveyed the same basic information at both time points). Means for each linguistic category in each group across time as well as inferential statistics for the consistent CUs are presented in Table 6. As expected, language changes were observed in the content-consistent narrative. The group effect for death words was again significant. There were also two significant effects for time, death-related words decreased and psychological detachment words increased from T1 to T2. Finally, there were significant group × time interactions for cognitions and death-related words. Chronic PTS participants used fewer death-related words and more cognitive expressions over time when remembering their experiences on 9/11, whereas the resilient-recovered group did not change in the use of these linguistic categories.

Discussion

There are two competing theories on how individuals remember PTEs over the course of time. The static view posits that memory for PTEs, unlike memory for ordinary experiences, is fixed and inflexible and does not change with the passage of time. A more recent, dynamic view regards memories for PTEs as similar to memory for other everyday events and thus malleable like other memories. We explored predictions from these theories by measuring consistency and change in memories for the events of 9/11 among a sample of high-exposure survivors. Because the results of previous studies of memory for trauma have been mixed, in part because of variations in methodology, we used both a standardized trauma memory questionnaire and a free-recall narrative trauma memory format obtained at both 7 and 18 months post-9/11. We also measured trajectories of PTS symptoms from these same time points. Across both methods, we found that participants' recollections of 9/11 changed between assessment points and that some of the changes were associated with their longitudinal course of PTS. The standardized trauma memory questionnaire data revealed that individuals who had exhibited either consistently low PTS (resilience) or a reduction in PTS after 18 months (recovered) remembered experiencing less subjective threat at 18 months than they had at 7 months post-9/11. However, these same participants did not change their memory for the objective facts of the event. By contrast, participants who experienced elevated PTS across time did not change their memory for the subjective threat of the 9/11 attacks. The chronic PTS group did vary in their memory for the objective facts of 9/11 but did not show a consistent pattern of directionality across time.

The more open-ended narrative trauma memory data also varied with the passage of time. We parsed the 9/11 narratives into CUs

Table 5
Correlations for Language Categories of the Entire Trauma Narrative and PTS Reported at T1 and T2

Measure	M	SD	1	2	3	4	5	6	7	8	9	10
1. PTS, T1	16.7	10.7	—									
2. PTS, T2	14.3	10.6	0.76***	—								
3. Emotions, T1	1.1	0.5	−0.06	−0.21	—							
4. Emotions, T2	1.1	0.5	−0.12	−0.04	0.41*	—						
5. Death, T1	0.1	0.1	0.46*	0.56***	−0.12	0.08	—					
6. Death, T2	0.1	0.1	0.17	0.25	−0.23	−0.16	0.35	—				
7. Cognitions, T1	3.2	0.8	−0.36	−0.18	0.37*	0.23	−0.10	0.01	—			
8. Cognitions, T2	3.4	0.9	−0.15	−0.03	0.27	0.42*	0.02	−0.23	0.58**	—		
9. Detachment, T1	21.3	3.1	−0.08	−0.27	0.02	0.11	0.09	−0.15	−0.37*	−0.32	—	
10. Detachment, T2	22.2	4.3	−0.17	−0.28	−0.06	0.25	0.16	0.07	−0.14	−0.22	0.71***	—

Note. N = 29. Language categories are presented by percentage scores, i.e., number of words that refer to the language expression of total number of words in the narrative. PTS = posttraumatic Stress; T1 and T2 = 7 and 18 months after the attacks.
* $p < .05$. ** $p < .01$. *** $p < .001$.

Table 6
Changes in Consistent CU Language Categories Reported at T1 and T2 as a Function of PTS Groups

	Chronic (n = 11)				Resilient-recovered (n = 18)				ANOVA		
	T1		T2		T1		T2				
Measure	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	Group $F(1, 27)$	Time $F(1, 27)$	Interaction $F(1, 27)$
Cognitions	2.3	(0.3)	3.1	(0.4)	2.4	(0.24)	2.9	(0.29)	0.34	2.53	3.33[a]
Emotions	0.7	(0.2)	1.1	(0.3)	1.0	(0.17)	0.1	(0.2)	0.09	0.74	2.71[b]
Death	0.2	(0.0)	0.1	(0.0)	0.0	(0.04)	0.0	(0.0)	9.09**	7.43**	5.05*
Detachment	22.0	(1.4)	26.2	(1.4)	22.5	(1.08)	23.8	(1.1)	0.60	9.34**	2.11

Note. CU = content unit; PTS = posttraumatic stress; T1 and T2 = 7 and 18 months after the attacks; ANOVA = univariate analysis of variance. Language expressions are presented by percentage scores, i.e., number of in the language category of total number of words in the narrative.
[a] $p = .07$. [b] $p = .11$.
* $p < .05$. ** $p < .01$.

that captured a single idea, thought, or feeling. Only one third of the CUs remained unchanged from T1 to T2. However, the proportion of the narratives that changed was not meaningfully related to PTS. When we examined the linguistic categories used in consistent CUs, we found evidence for changes in the way information was conveyed. Even though participants were describing the same experiences at each time point, overall, they used fewer death-related words and more words pertaining to psychological detachment when they described these memories at 18 months after 9/11. The chronic PTS group also evidenced a unique pattern of language change. Chronic PTS participants used more cognitive expressions to depict their traumatic experiences over time. They also used fewer death words, while still using death-related words in their accounts relatively often.

Considered together, these results indicate that, contrary to the traditional static perspective, memory for a PTE, like memories for other ordinary events, is not fixed but rather malleable. Even when survivors generate *free recollections,* which minimize directional biases inherent in questionnaires, their recollections tend to change.

There are several well-established mechanisms that account for changes in peoples' memories of ordinary events that can also be applied to memories for PTEs. It has been proposed, for example, that changes in memory are partly attributable to earlier and more recent experiences that share features with and thus become associated with a target event (Roediger & Karpicke, 2006). Everyday memory is also subject to normal processes of decay, such that memories become less accessible over time (Wixted, 2004). One could speculate, however, that the memory of a unique and extraordinary disaster of the magnitude of the September 11th attacks would be neither distorted by other experiences nor lost because of the passage of time.

An alternative explanation for changes in memory for PTEs is that the elevated arousal typically associated with such events impairs memory. It has been documented that arousal interferes with the coding of detailed information as attention is shifted to the more central aspect of the experience (Burke Heuer, & Reisberg, 1992; Hulse & Memon, 2006). If this were the case, we would expect that participants' personal narratives about their experiences in escaping from the attacks would remain relatively unchanged. We would also expect to find no apparent *directional* change in the recollections of 9/11 between assessment times. The current investigation reveals, however, that the narratives *decreased* in length and that participants used *more* psychological detachment words to describe their experiences escaping from the attacks.

Another possible factor that may account for the directional change in memory could be that at 18 months after 9/11, people who were resilient or had recovered from the events wanted to move forward with their lives and "put the past behind them" (Mollica, Caridad, & Massagli, 2007, p.577). The tendency to minimize the memory of the trauma over time is not well documented (Mollica et al., 2007). There could be several moderating factors to account for the inconsistent findings (Brewin, 2007). Previous studies of consistency in trauma memory examined veterans' recollections of war (Engelhard et al., 2008; Koenen et al., 2007; Roemer, Litz, Orsillo, Ehlich, & Friedman, 1998; Southwick et al., 1997), and it is possible that in the context of a coherent military culture, memories are amplified rather than decreased. Also, these studies mainly used a binary questioning approach, whereby veterans' recollections were assessed in the first months or years after the war. Other studies involved clinical samples of survivors with PTSD undergoing treatment, in which case the therapeutic context would influence the natural course of the unfolding memory (Foa et al., 1995).

Limitations and Conclusion

There were several limitations to our study worth noting. Primary among these was that our first assessment occurred 7 months after 9/11. It is possible, therefore, that important changes in trauma memory or its relation to PTS had occurred before our study. Another issue related to the confusion and readjustment after the attacks is the relatively high (20%) attrition rate of participants who did not complete the interview assessments at both time points. Attrition was caused primarily by participants who relocated after September 11th. Nonetheless, this is an important issue that introduces potential sample biases for the longitudinal analyses. In that same vein, although our sample is comparable in size with other studies that have used narrative data and we enlisted only individuals who had been *highly* exposed to the attacks (i.e., in or near the WTC), the relatively small size of our sample in comparison with other trauma studies again raises the issue of possible sample biases. An additional limitation is that we

did not obtain objective measures of participants' mental health. The primary outcome measure we used, the PSS-SR, has shown adequate validity (Coffey et al., 2006), and in our previous studies, we were able to validate longitudinal trajectories based on the PSS-SR against ratings from participants friends/relatives (Bonanno et al., 2005). Nonetheless, it will be important for further studies of this nature to use wider and potentially more objective outcome measures.

Within the context of these limitations, the current investigation provides important evidence associating changes in the memory for trauma with posttrauma mental health. Although there has been controversy about the nature and fixedness of memory for traumatic life events, our findings clearly indicate across divergent methodological approaches that trauma memory changes over time and that the change in trauma memory is related to changes in trauma adjustment. As this study demonstrates, examining the content-consistent trauma narrative for changes in language is an important assessment tool. At a broader level, our findings suggest that by nature people strive to gain some distance from potentially traumatic experiences and to put the memory of the experience behind them. Resilient and recovering people memorialized their 9/11 experiences as less traumatic by downgrading negative appraisals of the event. By contrast, in chronic PTS, this natural downgrading of the memory tends not to occur. Not surprisingly, effective treatments for PTSD, such as exposure therapy, aim at helping trauma survivors render their trauma memories as more benign.

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