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Reactions to and Memories for the September 11, 2001 Terrorist Attacks in Adults with Posttraumatic Stress Disorder

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SUMMARY

We examined emotional reactions to and subsequent memory for the September 11, 2001 terrorist attacks in individuals with a history of posttraumatic stress disorder (PTSD). Surveys were conducted among clients, staff, and visitors of a Veterans Administration Hospital approximately one month and again 10 months after the attacks. As compared to a trauma-control group matched on age, sex, education, and veteran status, PTSD participants reported being more negatively affected by the attacks in the follow-up, but not in the initial survey. PTSD and matched trauma control participants were similar in various measures of their initial autobiographical memory and event memory for factual details of the attacks. However, within-subject comparison revealed significant forgetting over the 9 months in event memory only for the PTSD participants. Furthermore, PTSD participants exhibited a tendency to inflate the emotional aspects of their memory over time. Finally, only in the PTSD group, age was negatively correlated with event memory, suggesting an accelerated memory decline with age associated with PTSD. Copyright © 2003 John Wiley & Sons, Ltd.

Two types of memory disturbances are closely associated with posttraumatic stress disorder (PTSD): recurrent intrusive thoughts or memories of trauma and deficits in episodic memory function (Elzinga & Bremner, 2002). Individuals with PTSD often report involuntary recollections (e.g., flashbacks) of the traumatic experience (e.g., Brewin, 1998; Reynolds & Brewin, 1999) that are extremely vivid and often accompanied by heightened physiological reactivity. Memories of previous trauma appear to be readily revived in individuals with PTSD by various environmental cues, such as events that resemble the original trauma. For example, studies have shown that Vietnam veterans with higher levels of PTSD symptoms before Operation Desert Storm tended to report more revived memories of their experience in Vietnam during and after Operation Desert Storm than before (Long, Chamberlain, & Vincent, 1994; Wolfe, Brown, & Bucsela, 1992).

Individuals with PTSD also show deficits in various aspects of episodic memory function. First, individuals with PTSD appear to have difficulty in accessing their own non-traumatic autobiographical memories. For example, McNally, Lasko, Macklin, and Pitman (1995) reported that compared to trauma-control participants, individuals with

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PTSD took longer to retrieve a specific personal memory in response to a positive or neutral cue. The difficulty in accessing specific autobiographical memories also appears to be positively correlated with severity of PTSD symptoms (McNally, Litz, Prassas, Shin, et al., 1994). Second, inaccuracies have been observed in PTSD participants' memories for non-trauma related aspects of their personal past. For example, Johnson-Greene et al. (1997) examined the accuracy of recollection of education attainment in 116 individuals with diverse psychiatric diagnoses, including PTSD. Participants with PTSD (and also participants with alcoholism) over-estimated their educational achievement to a greater extent than the controls. Third, there is growing empirical evidence that individuals with PTSD resulting from a wide variety of trauma (e.g., combat, motor vehicle accident, interpersonal violence) have impaired memory for presented items on standard neuropsychological and laboratory episodic memory tasks (see Buckley, Blanchard, & Neill, 2000; Krystal, Bennett, Bremner, Southwick, & Charney, 1995; McNally, 1998; Wolfe & Schlesinger, 1997, for reviews). Further, some studies suggest that individuals with PTSD resulting from sexual abuse or interpersonal violence may be more likely to falsely remember items that were not presented but are semantically related to presented items (Bremner, Shobe, & Kihlstrom, 2000; Zoellner, Foa, Brigidi, & Przeworski, 2000). Interestingly, impaired performance (lower accuracy and/or greater tendency for memory distortion) on such episodic memory tasks appears to be limited to positive and neutral items: Individuals with PTSD typically do not show deficits in memory for negative or trauma-related items (e.g., Amir, McNally, & Wiegzrtz, 1996; McNally, Metzger, Lasko, Clancy, & Pitman, 1998; Vrana, Roodman, & Beckham, 1995). However, previous studies have reported PTSD symptoms being associated with increased inconsistencies in two repeated reports of previous trauma exposure in combat veterans (Roemer, Litz, Orsillo, Ehlich, & Friedman, 1998; Southwick, Morgan, Nicolaou, & Charney, 1997) and witnesses of interpersonal violence (Schwarz, Kowalski, & McNally, 1993). Thus, it remains to be clarified how individuals with PTSD remember exceptionally emotional, autobiographical events compared to individuals without PTSD.

Here we explore the memory of individuals with PTSD for a traumatic public event that occurred after the onset of their disorder. A study by Brunet Boyer et al. (2001) suggested that symptomatic response to subsequent trauma is positively correlated with the level of PTSD symptoms from previous trauma. Thus, we probed for both symptomatic reactions (e.g., intrusive thoughts) and memory in individuals with previous histories of trauma, with and without PTSD.

THE PRESENT STUDY

The recent terrorist attacks on the US have resulted in tremendous personal losses for many individuals and raised widespread concerns about personal safety. This national tragedy provided a rare opportunity for examining emotional reactions to and subsequent memories for a profoundly shocking public event in individuals with PTSD. We are aware of no previous studies of individuals with PTSD that had the potential to assess emotional reactions, as well as memories, under these kinds of extreme circumstances. We targeted our study at a range of people associated with a Veterans Administration hospital where we expected that a significant proportion of the participants would have had trauma experiences prior to the terrorist attacks (e.g., veterans who had been involved in military action on previous occasions), and that some of them would have a diagnosis of PTSD.

Several hypotheses were advanced. It was expected that PTSD participants would respond more negatively to the terrorist attacks. In particular, it was expected that individuals with PTSD would experience more post-trauma symptoms related to the attacks, especially more frequent and more intense intrusive thoughts of the attacks. It was also expected that regardless of PTSD status, intrusive thoughts would have an effect on memory for the attacks. For example, frequent intrusive thoughts of the attacks may be associated with increased vividness and subjective confidence about memories (Garry, Manning, Loftus, & Sherman, 1996; Suengas & Johnson, 1988). Based on previous findings showing that individuals with PTSD typically do not exhibit deficits in memory for negative or trauma related items (e.g., McNally, Metzger et al., 1998), it might be expected that PTSD participants would remember the attacks equally well as participants without PTSD. On the other hand, previous studies in which individuals with PTSD showed no memory deficits for negative or trauma-related items were laboratory studies in which materials such as words or pictures were used as stimuli. It is possible that, given its magnitude of devastation and personal relevance, an event as significant as the 9/11 attacks would induce levels of emotion, self-focus and/or intrusive thoughts/rumination that might produce memory distortion. Finally, it was expected that age would be negatively correlated with memory for the attacks, especially among the PTSD participants (Bremner & Narayan, 1998).

METHODS

Participants

Initial survey participants

Initial survey questionnaires were handed out to 428 clients, staff, and visitors of the Veterans Administration Connecticut Healthcare System and 131 questionnaires were returned, for a return rate of 30.6%. Among the initial survey participants (age $M = 53.08$ years, $SD = 14.38$, range = 22–88; 52.8% were male; 46.7% had a college degree), 49.2% were veterans of the US military, 53.4% reported that they had been in a life-threatening situation in their life before the September 11 terrorist attacks (i.e., they answered 'yes' to the question 'Have you ever been in a situation that involved actual or threatened death or serious injury, either to yourself or to another person'), and 18.3% reported that they had been diagnosed with PTSD. On average, the delay interval for completing the initial questionnaire (i.e., the interval between September 11, 2001, and the day the questionnaire was completed) was approximately one month (Median = 30 days, range = 27–74 days).

The PTSD group consisted of 24 participants who reported that they had been in a life-threatening situation and that they had been diagnosed with PTSD (age $M = 53.65$ years, $SD = 16.03$, range = 22–83). The group included 20 males and 4 females; 8 reported that they had a college degree; 22 were veterans).[1] Sixteen of the 24 PTSD participants reported diagnoses of psychiatric disorders other than PTSD. All 24 PTSD participants reported that they had received treatment (5 received psychotherapy, 6 received

[1]The PTSD group ($n = 24$) included 4 females, 18 males, and 2 participants did not report their sex. Both who did not report sex were veterans of the US military. Given that the majority of the veteran PTSD participants were male and that the two participants who did not report sex were veterans with PTSD, the two missing data points were replaced by male. One male veteran participant did not report his level of education. Because male veterans with PTSD were 13 to 3 without a college degree, the missing data point was replaced with 'no college degree'. In addition, one male veteran who had no college degree did not report his age. The missing data on age was replaced by 54.53 years, the mean age of male veterans who had no college degree. With the missing data on demographic information replaced, the PTSD group consisted of 20 male veterans (4 with college degrees, 16 without), 2 female veterans with college degrees, and 2 female non-veterans with college degrees.

medication, 11 received both). Although we did not specifically ask if they were currently in treatment for PTSD, 20 PTSD participants reported they were on medication for PTSD and/or other psychiatric disorders. In addition, 10 PTSD participants reported a history of drug/alcohol abuse, of whom 9 had received treatment for substance abuse. Only 3 of these participants reported noticing an increase in use of drugs or alcohol since the attacks.

Twenty-four matched trauma control (MTC) participants were selected from the 46 participants who reported that they had been in a life-threatening situation but had not been diagnosed with PTSD. The MTC participants were selected so that the MTC group matched the PTSD group as closely as possible in age, sex, level of education, and veteran status (age $M = 55.92$ years, $SD = 15.24$, range = 24–83; 20 were male; 11 reported that they had a college degree; 21 were veterans).[2] The two groups were not significantly different on those criteria, nor did they differ in the delay interval for completing the initial questionnaire ($M = 31.6$ days vs. $M = 30.5$ days for PTSD and MTC participants, respectively). However, compared to the PTSD participants, the MTC participants were significantly less likely to have been diagnosed with psychiatric disorders other than PTSD (e.g., schizophrenia, obsessive-compulsive disorder, depression; $n = 9$ for the MTC group), $\chi^2 = 4.09$, $p < 0.05$, and to have a history of drug/alcohol abuse ($n = 3$ for the MTC group), $\chi^2 = 4.45$, $p < 0.05$.[3]

Follow-up survey participants

Approximately 8.5 months after the initial survey, a follow-up questionnaire was mailed to the 115 participants who had returned the initial questionnaire and provided a valid return address. Seventy-nine follow-up questionnaires were completed and returned. Based on participant-generated identification codes and demographic information, 75 of the 79 returned follow-up questionnaires were matched to the corresponding participant who completed the initial questionnaire. Thus, the valid return rate for the follow-up survey was 65.2%. Among the follow-up survey participants (age $M = 52.69$ years, $SD = 12.80$, range = 27–88; 48.6% were male; 53.3% had a college degree), 44.6% were veterans, 52.7% reported that they had been in a life-threatening situation, and 16.4% reported that they had a PTSD diagnosis. There was no statistically significant difference between participants who returned and those who did not return the follow-up questionnaire in age, sex, college education, veteran status, reported trauma history, diagnosis of PTSD, diagnosis of other psychiatric disorders, or history of drug/alcohol abuse. On average, the delay interval for completing the follow-up questionnaire was 10 months (Median = 304 days, range = 299–367 days).

Twelve of the original 24 PTSD participants returned the follow-up questionnaire. Among the 12 PTSD participants (age $M = 53.67$ years, $SD = 13.01$, range = 34–78), 9 were male; 6 had a college degree; 10 were veterans; 9 reported psychiatric disorders other than PTSD; and 4 had a history of drug/alcohol abuse. Thirteen of the original MTC participants returned the follow-up questionnaire. Among the 13 MTC participants

[2]With the procedures used, it was not possible to match groups on other potentially important variables. For example, compared to the MTC participants, the PTSD participants may have experienced more frequent or more severe trauma, or, there may have been undiagnosed PTSD in the MTC group.

[3]Analyses of covariance (ANCOVAs) were applied to rule out the possibility that psychiatric disorders other than PTSD and drug/alcohol abuse mediated the few differences that existed between the PTSD and the MTC groups in the initial survey. The group differences remained significant in the ANCOVAs, suggesting they were not entirely due to either other psychiatric disorders or drug/alcohol abuse. If PTSD, other psychiatric disorders, and substance abuse are etiologically interdependent or if they share some common factor(s), covaring these two factors may underestimate group differences (see Miller & Chapman, 2001).

(age $M = 60.69$ years, $SD = 13.59$, range = 34–83), 10 were male; 7 had a college degree; 11 were veterans; 6 reported psychiatric disorders other than PTSD; and 1 had a history of drug/alcohol abuse.

For both the PTSD and MTC groups, participants who completed the follow-up questionnaire did not significantly differ from those who did not in age, sex, college education, veteran status, or diagnosis of other psychiatric disorders. There was also no significant difference between PTSD and MTC follow-up survey participants in age, sex, college education, veteran status, diagnosis of other psychiatric disorders, or history of drug/alcohol abuse, nor did they differ in the delay interval for completing the follow-up questionnaire ($M = 308.7$ days vs. $M = 304.5$ days for PTSD and MTC groups, respectively).

Survey questionnaires

The initial and the follow-up questionnaires were modifications of those developed by the 9/11 Memory Consortium (see Acknowledgment). The initial and follow-up questionnaires included essentially the same questions: (1) personal information, such as age, sex, level of education, previous experience of trauma, history of psychiatric disorders; (2) general mood when completing the survey; (3) reactions and feelings in the first few days after the attacks; (4) reactions and feelings in the 'last day or two'; (5) media exposure and interpersonal interactions about the attacks; (6) estimates of the likelihood of future terrorist attacks in the US; (7) predictions of their own memory; (8) autobiographical memory about how they first heard about the attacks; (9) event memory about factual details of the attacks, and (10) background knowledge related to the attacks. The follow-up survey also asked participants to recall their initial ratings of their reactions to the events and their initial estimates of future terrorist attacks. This allowed us to examine their memory for their initial reactions and feelings, in addition to their autobiographical and event memory for the attacks. The follow-up survey also assessed current exposure to information via media and interpersonal contact. The format included rating scales, Yes/No, multiple choice, and open-ended questions.[4]

Coding and data reduction

Coding

A scheme was developed for coding answers to open-ended questions into response categories. Answers to event memory questions were first scored for units of correct information. For example, for the question 'What airline or airlines had planes hijacked,' the (correct) answer 'United and American ' was counted as 2 units of correct information, 1 for 'United,' 1 for 'American;' the answer 'United ' (a partial correct answer to the same question) was counted as 1 unit of correct information. Answers were also coded for number of intrusions. For example, if a participant answered 'American and Delta ' to the aforementioned question, it would be counted as 1 unit correct for 'American' and 1 intrusion for 'Delta.' Two coders, who were blind to the hypotheses of the study and to group membership, independently coded answers using the coding scheme. A randomly selected 30% of the questionnaires from the initial and follow-up surveys were assessed for coder agreement. Inter-coder reliability as measured by proportion of agreement was greater than 96.6% for open-ended (including event memory) questions.

The two coders also rated the contents of the answers to autobiographical memory questions on each survey for the amount of detail and the level of consistency across the

[4]Details of the survey questionnaires and of the measures used in the analyses are available from the first author.

two surveys. The amount of detail was rated on a scale from 0 (no information provided), 1 (information without specific detail), and 2 (specific detail), a scheme similar to that used by Neisser and Harsch (1992). The level of consistency between the two surveys was rated on a scale from 0 (direct contradiction), 1 (inconsistent but no direct contradiction), and 2 (consistent). Two coders independently coded a randomly selected 30% of the data. Inter-coder reliability as measured by proportion of agreement was greater than 80.1% for detail and consistency coding. All disagreements were resolved through discussion. The two coders then coded the remaining data.

Data reduction

To reduce the number of variables to a more manageable set and to reduce the probability of Type I errors, composite variables were created. In some cases, composites were averages of scores on the entire set of questions with similar content (e.g., autobiographical memory questions). In other cases, a principal component analysis (PCA) was conducted first: Answers to a particular set of questions with similar content (e.g., questions about general mood and feelings) were entered into a PCA with Varimax rotation to identify a limited number of factors. For each PCA, the factors were selected among the ones with Eigenvalues greater than 1 and on the basis of Scree plot. The proportions of variance the selected factors accounted for ranged from 45.5% to 92.7%. For each factor, items (i.e., questions) with factor loadings of 0.50 or greater were included in the composite scale. Reliabilities of the composite scales, as measured by Cronbach's α, ranged from 0.79 to 0.92. A composite scale score was then created for each factor by averaging scores on items on the scale (the items were listed in an order of descending factor loading). To increase the reliability of the factors, all PCAs and reliability analyses were conducted with the full sample in the initial survey.

Data reduction for the follow-up survey data was conducted in a similar way, except that instead of conducting a new set of PCAs with the follow-up survey data, results from the PCAs from the initial survey data were used. Reliability for each factor was computed with the full sample of the follow-up survey to ensure that the same set of items formed a reliable composite scale with the follow-up survey data. All items included have met this criterion. A composite scale score was then created for each factor, corresponding to the composite scores created for the initial survey. Composite scores thus created afforded direct comparisons of the answers to the same set of questions in the initial and follow-up surveys.

RESULTS

To examine potential differences between the PTSD and the MTC participants in their reactions to and memories for the attacks, we conducted three sets of analyses: 1) one-way (PTSD vs. MTC) multivariate analyses of variance (MANOVAs) on data from the initial survey ($n = 24$, $n = 24$ for the PTSD and the MTC group, respectively); 2) a similar set of one-way MANOVAs on data from the follow-up survey ($n = 12$, $n = 13$ for the PTSD and the MTC group, respectively); and 3) for those participants in the two groups who filled out both surveys, we conducted 2 (Time: initial survey vs. follow-up survey) $\times$ 2 (Group: PTSD vs. MTC) mixed MANOVAs, with time being a within-subject factor and group being a between-subject factor ($n = 12$, $n = 13$ for the PTSD and the MTC group, respectively). In addition, correlation coefficients were calculated among selected variables to examine predicted relationships. Because analyses of the initial survey data

revealed very few differences between the PTSD and the MTC participants' reactions to and memories for the attacks, we will provide only a brief description of the findings from the initial survey, and then focus on the findings from analyses of the follow-up survey data and the comparison between the two surveys.[5]

THE INITIAL SURVEY

Group differences

The PTSD and the MTC participants were significantly different on three measures of reactions to and memories for the attacks approximately 1 month after they happened: general mood when completing the questionnaire, reports of behavioral and emotional reactions in the first few days, and intrusions in memory for factual details of the attacks. In terms of mood when completing the survey, the PTSD participants reported higher levels of *Anger* (mad, angry, outraged, furious, enraged, offended, bitter, upset, annoyed, agitated, frustrated; $M = 3.77$) and *Fear* (frightened, fearful, afraid, terrified, worrying, nervous, panicky, tense; $M = 2.49$) than the MTC participants ($M = 3.16$ for *Anger*, $M = 1.96$ for *Fear*), univariate Fs$(1, 40) \geq 4.32$, ps < 0.05. The PTSD participants also remembered their behavioral and emotional reactions during the first couple of days after the attacks as stronger than did the MTC participants, multivariate $F(2, 45) = 5.33$, $p < 0.01$. More specifically, the PTSD participants reported more *Behavioral Disturbance* (disturbed sleep, being more jumpy than usual, being more depressed, being less interested in participating in normal activities, having nightmares, being more suspicious than usual; $M = 3.51$), than did the MTC participants ($M = 2.59$), univariate $F(1, 45) = 8.59$, $p < 0.01$. Although behavioral disturbance was positively correlated with current levels of *Anger* ($r = 0.37$, $p < 0.05$) and *Fear* ($r = 0.59$, $p < 0.001$) in the combined PTSD and MTC sample, the group difference in reported initial *Behavioral Disturbance* was not entirely due to the differences in current mood: With the effects of anger and fear covaried, the group difference in initial behavioral disturbance remained significant.[6] Finally, PTSD participants exhibited fewer intrusions ($M = 0.11$) than the MTC participants ($M = 0.30$) regarding the factual details of the attacks, univariate $F(1, 44) = 4.21$, $p < 0.05$.

Predicted correlations

Consistent with the hypothesis that PTSD may exacerbate the cognitive effects of aging (Bremner & Narayan, 1998), we found that for participants in the PTSD group, age was negatively correlated with the percent correct score for event memory, $r = -0.41$, $p < 0.05$; that is, older PTSD participants tended to remember fewer correct factual details of the attacks than did younger PTSD participants. This correlation was not significant for the MTC participants. Consistent with experimental studies showing that thinking about events influences vividness (e.g., Suengas & Johnson, 1988), with the PTSD and the MTC groups combined ($n = 48$), both frequency ($r = 0.35$, $p < 0.05$) and

[5]Due to missing data on various questions, the actual sample sizes for various analyses could be smaller than 48 for initial survey data and smaller than 25 for the follow-up survey data. The results we report are based on analyses with the largest available sample size for any given analysis. We also conducted a separate set of analyses on a complete data set, with missing values replaced with estimates obtained through SPSS EM (expectation-maximization) algorithm. The two sets of analyses revealed a very similar pattern of findings.

[6]ANCOVA was applied to rule out the possibility that general mood alone mediated the group differences in the level of behavioral disturbances. Insofar as anger and fear may be an aspect of PTSD, covaring these factors may underestimate group differences (see Miller & Chapman, 2001).

intensity/vividness ($r = 0.42$, $p < 0.01$) of intrusive thoughts of the attacks were positively correlated with vividness of autobiographical memory. In addition, frequency of intrusive thoughts was positively correlated with confidence in event memory ($r = 0.34$, $p < 0.05$) and confidence in background knowledge ($r = 0.36$, $p < 0.05$).

Summary

Approximately one month after the attacks, the PTSD and the MTC participants were remarkably similar in their reactions to the attacks: There was no significant difference between groups in the perceived effects of the attacks on their personal life (e.g., relationships with their family, friends, and coworkers); no significant difference in post-trauma symptoms such as frequency and vividness of intrusive thoughts about the attacks; no significant difference in perceived likelihood of future terrorist attacks; no significant difference in reports about how much they talked to other people, followed the media coverage, and overall how much they thought about the attacks. The PTSD and the MTC participants were also very similar in their autobiographical memory about how they first heard about the attacks, and incorrect memory for the factual details of the attacks and background knowledge related to the attacks. The few differences that did exist between the two groups were that the PTSD participants reported higher levels of current anger and fear than the MTC participants, that the PTSD participants reported their behavioral disturbance in the first few days as greater than did the MTC participants, and that the PTSD participants had fewer intrusions in their event memory than the MTC participants.

Post hoc power analyses indicated that with the sample in the initial survey ($n = 24$ for each group) and at $\alpha = 0.05$, the present study had adequate power to detect large (power = 0.77) or medium-sized effects (power = 0.40). It is thus reasonable to conclude that approximately one month after the attacks, there was little difference between the PTSD and the MTC participants in their reactions to and memories for the attacks on many aspects measured in this survey.

THE FOLLOW-UP SURVEY

Next, we present findings from analyses of potential differences between the PTSD and the MTC participants in the follow-up survey as well as possible effects of time and interactions between time and group. All significant effects are reported. It should be noted that when mixed MANOVAs were conducted, only participants with complete data on both surveys ($n = 12$ for the PTSD participants and $n = 13$ for the MTC participants) were included. Thus, the means of these participants on various measures in the initial survey were different from the means calculated with all the PTSD ($n = 24$) and the MTC participants ($n = 24$) who completed the initial survey included, although in all cases the differences between the group means were in the same direction.

Reactions to the Attacks (see Table 1)

General mood when completing the questionnaire

The PTSD participants reported a lower level of *Happy* feelings (glad, good, happy, cheerful, fine, enthusiastic, agreeable, amused) than the MTC participants, univariate $F(1, 20) = 6.62$, $p < 0.05$. In addition, the multivariate effect of time was significant, multivariate $F(3, 16) = 10.88$, $p < 0.001$, suggesting a significant change in general mood

Table 1. Reactions to the attacks

	Initial survey		Follow-up survey	
	PTSD ($n = 12$)	MTC ($n = 13$)	PTSD ($n = 12$)	MTC ($n = 13$)
General mood when completing the questionnaire (1 = not at all, 5 = very much so)				
Anger	3.64 (0.23)	3.17 (0.33)	2.90 (0.35)	2.36 (0.26)
Fear	2.20 (0.23)	2.23 (0.29)	2.40 (0.31)	2.14 (0.30)
Happy	1.94 (0.23)	2.47 (0.28)	2.28 (0.25)	3.22 (0.26)
Effects of the attacks on personal life (1 = not at all, 5 = very much)				
Negatively affecting personal life	1.75 (0.25)	1.67 (0.20)	1.83 (0.21)	1.33 (0.18)
Positively affecting personal life	1.92 (0.32)	2.87 (0.31)	1.72 (0.22)	2.44 (0.33)
Will have serious consequences	2.67 (0.40)	3.15 (0.22)	2.17 (0.39)	2.62 (0.37)
Post-trauma symptoms related to the attacks (1 = not at all difficult/never/not at all intense, 5 = very difficult/very often/very intense)				
Hard to concentrate	2.25 (0.41)	2.38 (0.31)	3.00 (0.30)	2.31 (0.29)
Frequency of intrusive thoughts	3.25 (0.33)	3.23 (0.30)	3.33 (0.36)	2.31 (0.26)
Intensity of intrusive thoughts	3.58 (0.34)	3.62 (0.29)	3.42 (0.36)	2.77 (0.36)
Avoiding people/reminders	2.33 (0.33)	1.85 (0.22)	2.08 (0.38)	1.46 (0.24)
Estimation of the likelihood of future attacks (in percent)				
Short-term likelihood	26.67 (8.49)	57.69 (7.73)	20.42 (5.31)	35.00 (7.62)
Long-term likelihood	58.33 (9.70)	71.92 (8.27)	62.50 (6.81)	75.00 (4.94)

Note: Numbers in parentheses are standard errors.

from the initial to the follow-up survey for participants in both groups. More specifically, the reported level of *Anger* decreased, and the reported level of *Happy* feelings increased, univariate Fs$(1, 16) \geq 10.41$, ps < 0.01.

Effects of the attacks on personal life

The multivariate effect of group was significant, multivariate $F(3, 21) = 3.94$, $p < 0.05$, suggesting that overall, the PTSD and the MTC participants were significantly different in perceived effects of the attacks on their personal life. Although this was not true for any of the individual measures that entered into the MANOVA, the PTSD participants tended to report greater *Negative Effects* (negatively affecting: the quality of relationships with family, relationships with friends/co-workers, performance at work/school) and less *Positive Effects* (positively affecting: the quality of relationships with family, relationships with friends/co-workers, performance at work/school) of the attacks on their personal life 10 months later. This was in contrast to the lack of significant differences in perceived effects of the attacks on personal life between the PTSD and the MTC participants at 1 month after the attacks.

Post-trauma symptoms related to the attacks

In contrast to the lack of significant differences between the two groups at 1 month, the PTSD participants reported significantly more frequent intrusive thoughts about the attacks 9 months later than the MTC participants, univariate $F(1, 23) = 5.50$, $p < 0.05$. There was a significant interaction between time and group on frequency of intrusive thoughts, univariate $F(1, 23) = 3.16$, $p < 0.05$: Although the frequency of intrusive thoughts decreased significantly for the MTC participants over the 9-month span, $F(1, 12) = 14.90$, $p < 0.01$, the frequency of intrusive thoughts remained at the same level for the PTSD participants.

Estimates of the likelihood of future attacks
The multivariate effect of time was significant, multivariate $F(2, 22) = 4.33$, $p < 0.05$. Specifically, estimates of *Short-Term Likelihood* of future attacks (the likelihood of another attack within the next week or the next month) decreased over the 9-month span, univariate $F(1, 23) = 5.51$, $p < 0.05$.

Rehearsing the event
No group differences were found for activities that rehearsed the 9/11 events (e.g., talking to others, media exposure). Across groups, rehearsal decreased after 9 months, Fs$(1, \geq 20) \geq 9.59$, ps < 0.01. From the initial to the follow-up survey, the amount that participants talked to other people decreased from $M = 2.80$ to $M = 1.65$; the amount of media exposure decreased from $M = 4.08$ to $M = 3.04$; and the amount of generally thinking about the attacks decreased from $M = 4.52$ to $M = 3.76$ (1 = very little, 5 = very much).

Memory related to the event (see Table 2)

Memory for estimates of the likelihood of future attacks
Participants indicated in the follow-up survey how likely they had thought it would be, in the first month after the attacks, that there would be another terrorist attack during the 'next week,' 'next month,' 'next year,' and 'next 5 years.' In other words, we queried them about their memory for how they had felt at 1 month. Two composite scores were created, one for *Short-Term Likelihood*, the other for *Long-Term Likelihood*. The estimates from the follow-up survey were compared to those provided in the initial survey in a mixed MANOVA. A significant interaction between group and time emerged, multivariate $F(2, 22) = 3.54$, $p < 0.05$. Analysis of simple effects suggested that the PTSD participants remembered their initial estimates of the *Short-Term-Likelihood* of another attack being significantly higher then they actually were, $F(1, 11) = 4.22$, $p = 0.06$, whereas the MTC participants remembered their estimates to be slightly lower, although not significantly. Thus, there was inflation in the PTSD participants' memory about how they felt about the *Short-Term Likelihood* of future terrorist attacks 9-month earlier.

Memory for rehearsing the event
Participants estimated, in the follow-up survey, the amount of rehearsal they engaged in during the first few days and weeks after the attacks (e.g., the number of people they talked to, and how much they talked to other people, about the attacks in the first few days; the number of hours they spent following media coverage in the first few days; and so on). These new estimates were compared to the corresponding estimates they had given in the initial survey, using a mixed MANOVA. No significant effect of group or time emerged, suggesting that both the PTSD and the MTC participants remembered quite well their initial rehearsal-related activities.

Memory for initial behavioral and emotional reactions
At the follow-up survey, PTSD participants remembered behavioral and emotional reactions to the attacks in the first few days as being stronger than did the MTC participants, multivariate $F(2, 22) = 8.39$, $p < 0.01$. The PTSD participants remembered more *Behavioral Disturbance* (e.g., disturbed sleep, being more jumpy than usual), univariate $F(1, 23) = 10.60$, $p < 0.01$, compared to the MTC participants, and, in fact, they had initially reported more behavioral disturbance. However, the PTSD participants

Table 2. Memory related to the event

	Initial survey		Follow-up survey	
	PTSD ($n = 12$)	MTC ($n = 13$)	PTSD ($n = 12$)	MTC ($n = 13$)
Memory for estimates of the likelihood of future attacks (in percent)				
STM likelihood	26.67 (8.49)	57.69 (7.73)	44.17 (9.82)	47.69 (6.64)
LTM likelihood	58.33 (9.70)	71.92 (8.27)	60.83 (7.61)	73.85 (6.75)
Memory for rehearsing the event				
Number of people talked first few days (1 = 1–3, 2 = 4–6, 3 = 7–10, 4 = 11–15)	3.08 (0.51)	3.38 (0.35)	3.67 (0.45)	4.09 (0.34)
How much talked first few days (1 = very little, 5 = very much)	3.83 (0.42)	4.54 (0.22)	4.33 (0.26)	4.64 (0.20)
Hours following media first few days	4.77 (0.92)	5.86 (1.18)	5.05 (1.12)	4.56 (0.87)
How much followed media first month (1 = very little, 5 = very much)	3.67 (0.40)	4.46 (0.22)	4.17 (0.34)	4.91 (0.09)
Memory for initial behavioral and emotional reactions (1 = not at all, 5 = very much)				
Behavioral disturbance	3.41 (0.28)	2.62 (0.21)	3.68 (0.20)	2.65 (0.24)
Worry	2.70 (0.33)	3.26 (0.30)	3.25 (0.32)	3.26 (0.25)
Autobiographical memory				
Proportion answered	0.87 (0.05)	0.97 (0.02)	0.98 (0.02)	0.87 (0.07)
Detail ratings (0 = no valid information, 1 = valid information but no specific detail, 2 = specific detail)	1.09 (0.09)	1.20 (0.07)	1.16 (0.05)	1.06 (0.10)
Vividness ratings (1 = very vague, 5 = very vivid)	4.59 (0.17)	4.72 (0.14)	4.69 (0.12)	4.67 (0.12)
Consistency ratings (0 = direct contradiction, 1 = inconsistent but no direct contradiction, 2 = consistent)	—	—	1.29 (0.07)	1.34 (0.08)
Event memory				
Correct details (proportion)	0.76 (0.06)	0.62 (0.08)	0.64 (0.07)	0.58 (0.06)
Intrusion errors (proportion)	0.06 (0.04)	0.23 (0.06)	0.17 (0.07)	0.37 (0.10)
Confidence in details (1 = guessing, 5 = sure I am right)	4.13 (0.15)	4.14 (0.14)	3.82 (0.19)	3.78 (0.18)
Background knowledge				
Correct knowledge (proportion)	0.58 (0.09)	0.35 (0.08)	0.40 (0.09)	0.29 (0.09)
Confidence in knowledge (1 = guessing, sure I am right)	3.00 (0.34)	3.23 (0.31)	2.93 (0.38)	2.86 (0.25)

Note: Numbers in parentheses are standard errors.

remembered having been more worried than they actually were initially: When the remembered level of *Worry* in the follow-up survey was directly compared to that in the initial survey, the difference was significant (in the direction of overestimation) for the PTSD participants, $F(1, 11) = 8.74$, $p < 0.05$, but not for the MTC participants. Such inflation over time in reports of emotional trauma has also been observed by other researchers (e.g., Roemer et al., 1998; Southwick et al., 1997).

Autobiographical memory

No significant group effect was observed, suggesting that 10 months after the attacks, autobiographical memory was very similar for the PTSD and the MTC participants in

proportion of questions answered, amount of detail in the answers, subjective vividness of the memory, and the consistency between the two reports across a 9-month span. The multivariate time effect was not significant, suggesting that autobiographical memory about how participants first heard about the attacks did not change significantly between the initial and the follow-up surveys. However, there was a significant univariate interaction between time and group for the proportion of autobiographical memory questions answered, univariate $F(1,\ 23) = 8.48,\ p < 0.01$. Analysis of simple effects revealed that although the proportion of autobiographical memory questions answered by the MTC participants did not change significantly from the initial to the follow-up survey (if anything, the percentage was lower), the PTSD participants answered a *higher* proportion of the autobiographical memory questions in the follow-up survey than they did in the initial survey, $F(1, 11) = 7.33$, $p < 0.05$, providing another indication of inflation in memory over time in the PTSD participants.

Event memory about factual details of the attacks

No significant effect of group emerged, suggesting that at approximately 10 months after the attacks, the PTSD and MTC participants were not significantly different in their event memory for the factual details of the attacks. There was a significant multivariate effect of time, multivariate $F(3, 20) = 5.53$, $p < 0.01$. Specifically, both the percent correct and the confidence of event memory decreased over time, univariate Fs$(1, 22) \geq 11.74$, ps < 0.01. Although the interaction between time and group was not significant, a significant decrease in percent correct occurred only for the PTSD participants, $F(1,\ 11) = 13.65$, $p < 0.01$. Thus, unlike autobiographical memory, which did not decline significantly over a 9-month span for either group, significant forgetting occurred for event memory about the details of the attacks for the PTSD participants.

Background knowledge related to the attacks

No significant effect of group emerged, suggesting that the PTSD and MTC participants were similar in their background knowledge related to the attacks 10 months after the attacks. The multivariate effect of time was not significant, however, there was a significant univariate effect of time for correct knowledge, univariate $F(1,\ 21) = 5.16$, $p < 0.05$. Participants remembered less correct background knowledge related to the attacks after 9-months, however, their confidence did not change significantly.

Predicted relationships

We examined the relationship between measures of intrusive thoughts and measures of accuracy, intrusions, vividness, and confidence of memory related to the attacks. With both groups combined ($n = 25$), frequency of intrusive thoughts at 1 month was significantly correlated with intrusions in event memory 9 months later ($r = 0.44$, $p < 0.05$).

Relationships among the three indices of memory inflation (i.e., the difference between the level of initial *Worry* as remembered in the follow-up and in the initial surveys, the difference between the remembered and the actual estimate of *Short-Term Likelihood* of future terrorist attacks, and the difference between the proportion of autobiographical memory questions answered in the follow-up and the initial surveys) were examined. The results indicated that inflation in autobiographical memory and inflation in memory for initial estimates of *Short-Term Likelihood* of future attacks were significantly correlated, $r = 0.50$, $p < 0.05$. To examine the possibility that inflation in memory was associated with

current mood, correlation coefficients were calculated between the inflation indices and composite scores for *Anger*, *Fear*, and *Happy* when completing the follow-up survey. Inflation in memory for the estimate of *Short-Term Likelihood* of future attacks was negatively correlated to current level of *Happy* ($r = -0.49$, $p < 0.05$).

Summary

More differences in reactions to and memories for the attacks were observed between the PTSD and the MTC participants after a longer delay interval, in spite of the reduced power in the follow-up survey (with the reduced sample size [$n = 12$ for the PTSD group and $n = 13$ for the MTC group] and $\alpha = 0.05$, the follow-up survey study had adequate power only to detect a large effect [power = 0.48]). The PTSD participants reported more negative and less positive effects of the attacks on their personal life than the MTC participants. The PTSD participants also reported more frequent intrusive thoughts of the attacks than did the MTC participants. In fact, the frequency of intrusive thoughts in the PTSD participants remained at the same level 9 months later. The PTSD participants were also less *Happy* than the MTC participants. However, PTSD and MTC participants were not significantly different in the perceived likelihood of future terrorist attacks or in reported activities that rehearsed the event (i.e., how much they talked to other people, followed media coverage, and overall how much they thought about the attacks).

Over time, both the PTSD and the MTC participants experienced fewer post-trauma symptoms related to the attacks, except for intrusive thoughts, which did not decline over time in the PTSD group. There was also a decrease over time in how much participants talked to other people, how much they followed media coverage, and how much they reported thinking about the attacks generally. The estimate of *Short-Term Likelihood* of future terrorist attacks decreased, and participants felt less *Anger* and more *Happy* as compared to 9 months earlier. Overall there was little evidence for forgetting in autobiographical memory, however, for the PTSD participants, forgetting occurred for factual details concerning the 9/11 attacks.

There were two interesting interactions between time and group in memory: Only the PTSD participants remembered their initial level of *Worry* in the first few days as greater than they reported 9 months earlier in the initial survey. In addition, the proportion of autobiographical memory questions answered increased over time for the PTSD participants. Together with the finding that the remembered initial estimate of *Short-Term Likelihood* of future attacks was higher than it actually was only in the PTSD participants, a consistent theme emerged that the PTSD participants had a tendency for inflation in emotional and personal aspects of their memory related to the attacks.

GENERAL DISCUSSION

More differences emerged between the PTSD and the MTC participants in the survey completed 10 months after the 9/11 attacks than one month after the attacks. Specifically, the PTSD participants indicated that the attacks had more negative and less positive impact on their personal life, and that they were having more intrusive thoughts than the MTC participants. Thus, across the two surveys, the pattern of results suggests that any greater difficulty PTSD participants' had in coping with the terrorist attacks was more evident in the long run. This particular finding mirrors the results from a recent study that examined vulnerability of psychiatric patients to psychological distress following the September 11

terrorist attacks (Franklin, Young, & Zimmerman, 2002). Although both psychiatric patients and medical patients were highly distressed on the day of the attacks, the level of psychological distress reported by the psychiatric patients was significantly higher than that of the medical patients 2–3 weeks after the attacks. It is interesting to note that similar to the current findings of few differences between PTSD and MTC groups on the initial survey at one month, in the Franklin et al. study, the level of distressing symptoms at 2–3 weeks after the attacks was not significantly different between psychiatric patients with and without preexisting PTSD.

It is not surprising that among the four post-trauma symptoms we probed, the one that significantly differed between the PTSD and the MTC participants in the follow-up survey was the frequency of intrusive thoughts about the attacks. Intrusive thoughts about past trauma are, after all, at the center of PTSD symptomatology (Reynolds & Brewin, 1999). The fact that PTSD participants did not experience a reduction in intrusive thoughts between the initial and the follow-up survey may reflect impaired capacity to inhibit fear conditioned memories in PTSD participants (see, e.g., Bremner, 1999 for a thorough discussion of potential neurobiological bases of this impairment). Findings from the present study further suggest that frequent intrusive thoughts in individuals with PTSD are not limited to the trauma that originally led to PTSD. Intrusive thoughts may also occur for subsequent negative events experienced after the onset of PTSD. Thus, individuals with PTSD may constitute a particularly vulnerable group after profoundly negative significant life events such as the 9/11 terrorist attacks. It remains to be seen whether such effects are limited to subsequent events that are particularly similar to the original trauma (e.g., whether our group, being composed mostly of veterans, was particularly affected because the attacks were war-related, involved airplanes, destruction of property and lives, etc.).

Findings from the present study also suggest that regardless of PTSD status, intrusive thoughts may have an impact on memory associated with the event. As predicted, higher frequency and vividness of intrusive thoughts of the attacks were associated with increased vividness of autobiographical memory for how individuals first heard about the attacks (e.g., Suengas & Johnson, 1988). However, we also found that frequency of intrusive thoughts at 1 month after the attacks was associated with increased intrusions in remembering factual details of the attacks 9 months later. Reynolds and Brewin (1998, 1999) suggested that intrusive thoughts reported by individuals with PTSD may reflect appraisal of the trauma and its sequelae rather than rehearsal of the trauma event itself (see also Ehlers, Hackmann, Steil, Clohessy et al., 2002). If intrusive thoughts of the attacks focused more on personal and emotional, rather than factual, details of the attacks it would not necessarily enhance the accuracy of memory (Hashtroudi, Johnson, Vnek, & Ferguson, 1994). That is, the impact of emotion on memory depends on what the emotion leads the person to attend to or rehearse (e.g., Johnson, Nolde, & De Leonardis, 1996).

Consistent with findings from laboratory-based studies in which PTSD participants typically do not exhibit deficits in memory for negative or trauma-related materials (e.g., McNally, Metzger et al., 1998), we found that initially PTSD and the MTC participants were similar in autobiographical memory and event memory about the attacks. Further, the PTSD and the MTC participants were similar in background knowledge related to the attacks in both the initial and the follow-up surveys. However, we also found that significant forgetting in event memory occurred only for the PTSD participants across a 9-month interval. In addition, age was negatively correlated with event memory only in the PTSD group, suggesting an accelerated memory decline with age in individuals with PTSD (Bremner & Narayan, 1998; Golier, Yehuda et al. 2002). Thus, it appears that for

memories of very negative events such as the 9/11 terrorist attacks, individuals with PTSD may experience memory deficits that may not show up immediately.

Another important finding from the present study is that the PTSD participants exhibited a tendency for inflation in various aspects of their memory related to the attacks. What is interesting is that despite the tendency for memory inflation, the PTSD participants did not make more, and in fact made fewer, intrusions when answering questions about factual details of the attacks in the initial survey. Rather, the tendency for inflation was restricted to emotional or personal aspects of memory. In inflating their initial level of worry and initial estimate of the short-term likelihood of future attacks, participants, in effect, were misremembering how threatened they initially felt. Thus, individuals with PTSD did not show a general distortion of memories, but a more selective distortion of affectively-charged information. Unlike previous studies (Roemer et al., 1998), there was some indication that at least some of the inflation was related to the PTSD participants' current mood.

In summary, findings from the present study suggest that PTSD and MTC participants were to a large extent similarly affected initially by the 9/11 terrorist attacks, but PTSD participants were more negatively affected in the long run. With respect to memory, PTSD and MTC participants were similar in various measures of their autobiographical memory and event memory related to the attacks. However, more sensitive within-subject comparison revealed an accelerated long-term forgetting in PTSD participants. Furthermore, PTSD participants exhibited greater memory deficits associated with aging. Finally, PTSD participants exhibited a tendency to inflate the emotional aspects of their memory. These findings suggest that laboratory studies, which tend to rely on less intense and relevant stimuli and short retention intervals, may underestimate memory deficits for negative events associated with PTSD. It should be emphasized that these results do not imply a causal relation between any particular feature of PTSD (e.g., chronic stress; experience of frequent, extreme emotion; selective rehearsal of emotional rather an factual features of experience) and memory deficits. Although groups can be matched on variables such as age and experience of previous trauma, PTSD and control groups typically differ in many ways, including in the drugs they are taking, and the incidence of other psychiatric diagnoses. Nevertheless, because disturbances of emotion and memory are defining features of this disorder, accurately characterizing the nature of the emotional responses and qualities of memories of individuals with PTSD is important for advancing both theoretical understanding of and practical treatment for PTSD.

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