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Event Memory and Autobiographical Memory for the Events of September 11, 2001

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SUMMARY

This research compares event memory and autobiographical memory for an event that was experienced to be more distressing, with more significant and widespread consequences than was any other event for which memory has been studied in a large sample. Memory for the events of September 11 was assessed seven weeks later in three samples: (a) 275 college students from Manhattan; (b) 167 college students from California; and (c) 127 college students from Hawaii. Whereas event memory was most accurate in the New York sample most involved in and most distressed by the events, autobiographical memory was reported with the least detail in this sample. This finding is consistent with the prediction that it is the synergy of arousal and rehearsal that affects memory for stressful events. Constructive memory distortions are also evident in the data; 73% of the respondents reported (incorrectly) that on September 11, they saw on television, the videotape of the first plane striking the first World Trade Center tower. Copyright © 2003 John Wiley & Sons, Ltd.

A significant body of research on eyewitness memory has been published in the past few decades, and although much of this research is generalized to situations that involve memory for real and stressful events, little of this research actually has involved memory for real and stressful events. In fact, there is rarely an opportunity to conduct research on memory for real and stressful events, especially if researchers are seeking an adequate size sample of witnesses.

On the morning of September 11, 2001, a series of events transpired that simultaneously shocked a wide cross-section of people across the United States and around the world. This quasi-experimental study took advantage of this national disaster to examine several interrelated issues about memory for a stressful event, specifically, the degree to which stressful events persist in memory and follow predictable patterns, the extent to which this is a function of whether the emotionality attaches to the event memory or to the perceiver's autobiographical memory, whether stressful events are remembered differently as a function of the involvement and distress of the perceiver, and the extent to which there are constructive distortions in memory for a stressful event.

Seven weeks after September 11, three samples of people completed a questionnaire on (a) memory for the events of September 11 and (b) their autobiographical memory for September 11. These three samples were: (a) 275 college students from Manhattan,

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New York; (b) 167 college students from California; and (c) 127 college students from Hawaii. Based on the findings of several previous studies (Conway et al., 1994; Neisser et al., 1996; Pillemer, 1984), it was predicted that the degree of involvement in a stressful event would enhance memory for the event. These three groups were selected because they varied in their involvement in the events of September 11 and consequently were predicted to vary in the level of distress experienced. It is predicted more specifically that involvement and distress will differentially affect event memory (memory for the external events of September 11) and autobiographical memory (memory for the personal circumstances in which one first learned of these events).

Memory for a stressful event

The primary motivation for this study was to assess the accuracy and specificity of memory for a stressful event. This study is unique in that the events of September 11 were experienced to be more stressful with more significant and widespread consequences, than were perhaps any other event that has been the focus of previous research on this topic. This includes memory for the explosion of the Challenger Space Shuttle (Bohannon, 1988; Bohannon & Symon, 1992; McCloskey, Wible, & Cohen, 1988; Neisser & Harsch, 1992), the 1989 Loma Prieta earthquake (Neisser et al., 1996), the Hillsborough, England, soccer tragedy (Wright, 1993), the O.J. Simpson verdict (Schmolck, Buffalo, & Squire, 2000), the attempted assassination of President Reagan (Pillemer, 1984), and even the assassinations of U. S. President Kennedy (Brown & Kulik, 1977) and Swedish Prime Minister Olof Palme (Christianson, 1989). This claim applies as well to the more extensive research on memory for stressful events (see Pezdek and Taylor, 2002, for a review of this research.) Because the 'arousal hypothesis' is often proposed to explain why experiencing an event directly is more memorable than just hearing about it (Christianson, 1992; Gold, 1992), it is important to examine memory for events that were highly arousing and truly stressful.

The early research on 'flashbulb memories' suggested that highly emotional events 'leave a *scar* upon the cerebral tissues' (James, 1890, p. 670). And Brown and Kulik (1977) described memories for the assassination of President Kennedy as '. . . almost perceptual.' (p. 74). Although a debate has ensued for the past two decades regarding whether it is necessary to postulate a special memory mechanism to explain the processing of stressful events (McCloskey, Wible, & Cohen, 1988; Nadel & Jacobs, 1998; Neisser, 1982), in fact, many characteristics of memory for nontraumatic events apply to memory for traumatic events as well (Pezdek & Taylor, 2002). This study more specifically examines the effect of stress separately on event memory and autobiographical memory.

Comparisons of autobiographical memory and event memory

Despite the fact that Brown and Kulik (1977) first attributed the term 'flashbulb memory' to autobiographical memory for stressful events, the concept is frequently assumed to characterize stressful event memory as well. This is one of the few studies that separately examines event memories and autobiographical memories that were derived from the same stressful event. Event memory questions assessed participants' memory for the events that transpired in the terrorists' attacks such as, 'How much time passed between when the first tower was struck and when it collapsed?' Autobiographical memory questions probed participants' memory for their own experience when they first heard of the terrorists' attach, including location, informant, activity, day and time, and others

present. Although several researchers have reported unique memory characteristics that differentiate between personal memories and event memories (Greenwald, 1980; Rogers, Kuiper, & Kirker, 1977), other researchers have reported that self-schemata operate similarly to event schemata (Bower & Gilligan, 1979; Kennan & Baillet, 1980).

One interpretation of the finding that people more involved in an emotionally charged stressful event remember their experience of the event better than people less involved in the event is the narrative hypothesis of Neisser, et al. (1996). Accordingly, stressful events are likely to be transferred into narrative constructions and frequently rehearsed as such. It is thus the repeated rehearsal that leads to better memory for the events. This study tests an extension of the narrative hypothesis. It is proposed that a stressful event and people's autobiographical experience of the event are perceived and processed separately, resulting in separate memories. Accordingly, the emotions produced by the event could be attached to the external event or to one's personal experience of the event, and whichever of these two is more vivid will be associated in memory with relatively more of the emotions. Because more vivid emotional information is more readily available in memory and more likely to be rehearsed, it is the more vivid and emotionally charged aspect of a stressful experience—either the event memory or the autobiographical memory—that will receive relatively more narrative rehearsal and be more accurately retained. It is thus the synergy of arousal and rehearsal that affects memory.

In this study, it is hypothesized that for the participants who themselves were more involved in and distressed by the terrorists' attack, specifically, the New Yorkers, the events that transpired were monitored more carefully because these events more directly and more immediately threatened them. Thus, the emotionality of the situation was more likely to be attached to their memory for these events that they were so vigilantly monitoring, than to their memory for their personal experiences, and it is their event memory that is predicted to have received more narrative rehearsal. Consequently, their event memory is predicted to be higher and their autobiographical memory is predicted to be lower relative to the other groups.

On the other hand, for the participants from California and Hawaii who were predicted to be less personally involved in and less distressed by the terrorists' attack, they were less likely to be vigilantly monitoring the details of the events that transpired. Thus, the emotionality of the situation was more likely to be attached to their autobiographical memory than to their event memory, and it is their autobiographical memory that is predicted to have received more narrative rehearsal. Consequently, for these participants, event memory is predicted to be lower and autobiographical memory is predicted to be higher relative to the New York sample.

Constructive distortions in memory for a stressful event

Dating back to the early research by Bartlett (1932), cognitive psychologists have known that story recall is a highly constructive process. People use schemas to comprehend events and consequently remember along with the event experienced, the embellishments and inferences that they derived from the schemas (Bower, Black, & Turner, 1979; Holtz & Pezdek, 1992). The extent to which memories for highly stressful events are subject to constructive memory distortions has received little attention. Brown and Kulik's (1977) concept of 'flashbulb memory' suggests an almost veridical memory representation for stressful events. If memories for stressful events include constructive distortions, this would argue against characterizing them as 'flashbulb memories.'

The questionnaire used in this study included two questions to assess whether memory for a stressful event includes constructive distortions. In summarizing the research on memory for traumatic events, Pezdek and Taylor (2002) concluded that many characteristics of memory for nontraumatic events also apply to memory for traumatic events, including distortions and gist-like features typical of constructive memories. In this study, it was predicted that distortions in memory would occur as a consequence of constructive memory processes.

METHOD

Participants

The three college samples included undergraduates at (a) Baruch College at City University of New York ($n = 275$), (b) Pomona College in Claremont, California ($n = 167$), and (c) the University of Hawaii, Manoa and Hilo ($n = 127$). The mean age of the three college samples was quite similar (NY: 18.91 years, CA: 19.15 years, HI: 20.78 years). The percentage of females ($M = 62\%$) exceeded the percentage of males ($M = 38\%$) at each site. The three groups were ethnically diverse. The dominant ethnic groups in New York were Caucasian (35%) and Asian (34%). The dominant ethnic group in California was Caucasian (74%). In Hawaii, the dominant ethnic group was Asian (52%), and 26% of this sample was Caucasian.

Procedure and materials

Questionnaires were completed in the seventh week after September 11. This was the earliest date possible given the time required to obtain an expedited IRB approval from each of the four participating universities. Faculty members or graduate students at each site recruited volunteers to complete the questionnaire from Introductory Psychology courses. Questionnaires were completed on site and were collected immediately.

There were three sections of the questionnaire. The multiple components of question 1 probed *autobiographical memory* for the events of September 11. In addition to prompting open-ended free recall ('Please describe in as much detail as possible, everything you remember about where you were and what you were doing when you *first heard of the attack on New York and in the hour or so thereafter.*'), this question prompted for information regarding location, activity, informant, time, and others present—the five attributes focused on in previous research on flashbulb memory (cf. Neisser & Harsch, 1992). Participants were also asked what was the first thing said to them and the first thing that they said upon hearing of the events of September 11. Questions 4 through 10 probed *event memory* for September 11. These questions are listed in Table 1. Both accuracy and confidence were obtained for the event memory questions. In particular questions 7, 8, and 9 assess temporal dimensions of event memory and questions 4 and 5 assess constructive memory distortions. Additional questions gathered demographic and personal information regarding participants and their circumstances on September 11.

Scoring the autobiographical data

Autobiographical memory was assessed from the responses to the first question in the questionnaire. The accuracy of the autobiographical memory responses cannot be

Table 1. Questionnaire items with mean response per group and the corresponding significance test indicated

4. On September 11, did you see the videotape on television of the first plane striking the first tower?				
Responded Incorrectly, 'Yes':	NY: 76%	CA: 61%	HI: 84%	$X^2(2) = 21.28$, $p < 0.001$
5. Was the Pentagon struck before the first tower collapsed?				
Responded Incorrectly, 'No':	NY: 38%	CA: 38%	HI: 44%	$X^2(2) = 1.58$, $p = 0.44$
6. The point of impact, where the first plane hit the North Tower, was between what floors?				
Mean Response (Correct: ∼90th)	NY: 88.89	CA: 71.72	HI: 78.03	$F(2, 431) = 25.82$, $p < 0.001$, $\eta^2 = 0.95$
Confidence:	NY: 3.68	CA: 2.78	HI: 2.74	$F(2, 431) = 16.58$, $p < 0.001$, $\eta^2 = 0.93$
7. How much time passed between when the first tower was struck and when it collapsed?				
Mean Response (Correct: 108 min)	NY: 62.21	CA: 61.51	HI: 63.33	$F(2, 505) = 0.01$
Confidence:	NY: 3.97	CA: 3.07	HI: 3.00	$F(2, 501) = 24.15$, $p < 0.001$, $\eta^2 = 0.95$
8. How much time passed between when the first tower was struck and when the second tower was struck?				
Mean Response (Correct: 18 min)	NY: 20.61	CA: 26.56	HI: 28.29	$F(2, 525) = 5.78$, $p < 0.01$, $\eta^2 = 0.84$
Confidence:	NY: 4.65	CA: 3.48	HI: 3.46	$F(2, 520) = 33.40$, $p < 0.001$, $\eta^2 = 0.98$
9. How much time passed between when the first tower was struck and when the second tower collapsed?				
Mean Response (Correct: 65 min.)	NY: 76.61	CA:107.46	HI: 87.03	$F(2, 471) = 3.85$, $p < 0.05$, $\eta^2 = 0.78$
Confidence:	NY: 3.75	CA: 2.65	HI: 2.76	$F(2, 466) = 27.57$, $p < 0.001$, $\eta^2 = 0.96$
10. The New York Stock Exchange was closed for how many business days following September 11?				
Mean Response (Correct: 3 days)	NY: 4.26	CA: 3.69	HI: 5.15	$F(2, 527) = 10.13$, $p < 0.001$, $\eta^2 = 0.90$
Confidence:	NY: 4.67	CA: 3.36	HI: 3.40	$F(2, 519) = 37.81$, $p < 0.001$, $\eta^2 = 0.96$

determined; the responses were coded for the amount of detail recalled. In coding these data, we followed the procedure of Neisser and Harsch (1992) to obtain Weighted Attribute Scores (WAS). Based on this coding scheme, the five most salient attributes of autobiographical memory are *location, informant, activity, day and time*, and *others present*. For each participant, each of these five attributes was coded 0, 1, or 2 to reflect how much detail was included in the response regarding that attribute. A score of 0 reflected that no information or incorrect information was provided; a score of 2 reflected that specific detailed information was provided. According to Neisser and Harsch (1992), *location, informant* and *activity* are considered major attributes because this information is significant in defining one's personal circumstances upon hearing of an event. *Day and time* and *others present* are considered minor attributes less critical to defining one's personal circumstances. The WAS is the sum of the scores on the three major attributes, plus a bonus point if the subject scored 3 or more (of 4 possible) on the two minor attributes. For each participant, the WAS ranged from 0 to 7.

Open-ended responses to the autobiographical memory question were also coded from 0 (no information provided) to 2 (specific information provided) for (a) memory for the first thing said to you, (b) memory for the first thing that you said, (c) degree of emotional

reaction noted, (d) degree of disbelief noted (i.e., 'I couldn't believe it had happened.' 'I thought I was watching a movie.'), and (e) the extent to which the respondent indicated that he or she went about their regularly scheduled day after hearing of the terrorists' attacks. The author and one graduate student together read and coded all responses. To maintain a high level of accuracy and consistency throughout the rating of the 569 transcripts, the judges compared their ratings after each set of four transcripts. All differences in ratings were reconciled by discussion.

RESULTS

The results confirm the hypothesis that the New York participants were more highly involved in the incident than were participants in the other two samples. The 275 New Yorkers were on average 27 blocks from the World Trade Center when they learned of the terrorists' attack. Twenty eight percent of the New Yorkers had friends or family members in the World Trade Center or on one of the four hijacked airplanes, compared to only 9% of the Californians, 4% of the Hawaiians.

In response to the question, 'Please circle the number indicating how you felt when you first realized that this was a terrorist attack on New York,' (range = 1–7), the New Yorkers ($M = 5.49$, $SD = 1.46$) rated this event as significantly more distressing than the Californians ($M = 4.95$, $SD = 1.48$) or the Hawaiians ($M = 5.16$, $SD = 1.41$), $F(2, 564) = 7.12$, $p < 0.001$, $\eta^2 = 0.88$. In addition, in their open-ended responses to the first question, New Yorkers were more likely to have expressed an emotional reaction, less likely to have indicated that they went about their regularly scheduled day after hearing of the terrorists' attacks, and, along with the Hawaiians, were more likely to have expressed disbelief (i.e., 'I thought I was watching a movie.'). A one way Analysis of Variance across the three groups revealed significant differences on each of these items (see Table 3).

Event memory

Key items from the questionnaire are included as Table 1 with the mean response per group and the significance level indicated for each. The degrees of freedom vary across the analyses of responses to these questions as all participants did not answer all questions. The results are reported separately for event memory and autobiographical memory. The responses to questions 6 and 10 probe memory for specific details of the events of September 11. These results are presented in Table 1. In response to question 6, 'The point of impact, where the first plane hit the North Tower, was between what floors?' there was a significant difference in accuracy among the three groups, $F(2, 431) = 25.83$, $p < 0.001$, $\eta^2 = 0.95$, with the New York sample being the most accurate. In response to question 10, 'The New York Stock Exchange was closed for how many business days following September 11?' there was also a significant difference in accuracy among the three samples, $F(2, 527) = 10.13$, $p < 0.001$, $\eta^2 = 0.90$. However, for question 10, although again the Hawaii sample was the least accurate, the California sample was most accurate ($M = 3.69$ days). This finding is inexplicable, however the responses may simply reflect differences in the familiarity of the individuals in each sample with the functioning of the stock market.

Temporal memory questions

Questions 7, 8, and 9 assess temporal memory for the events of September 11. Regarding responses to question 7, 'How much time passed between when the first tower was struck

and when it collapsed?' the mean response across the three groups was 62.22 minutes ($SD = 87.19$), substantially less than the correct response of 108 minutes, and the responses did not differ across groups, $F(2, 505) = 0.01$. Although from this study it is not possible to determine if the temporal compression of the events of September 11 increased over time, it is clear that for participants in all three samples, memory for the events was temporally compressed after seven weeks.

In terms of temporal memory for the more specific details of the events of September 11, response accuracy did significantly differ among the three groups, and again, the New Yorkers were more accurate than were participants in the other two groups. Regarding question 8, 'How much time passed between when the first tower was struck and when the second tower was struck?' responses differed significantly among the three samples, $F(2, 525) = 5.78$, $p < 0.01$, $\eta^2 = 0.84$. The New York sample was more accurate than the other two groups. Responses to question 9, 'How much time passed between when the first tower was struck and when the second tower collapsed?' followed the same pattern with the differences significant among the three groups, $F(2, 471) = 3.85$, $p < 0.05$, $\eta^2 = 0.78$.

Autobiographical memory

The autobiographical memory data present a pattern of results that is quite different from that reported with the event memory data. Autobiographical memory was assessed from the open-ended free recall responses and the questions prompting for information regarding location, activity, informant, time, and others present. In coding these data, we followed the procedure of Neisser and Harsch (1992) to obtain Weighted Attribute Scores (WAS) (Range = 0 to 7). Mean WAS and mean scores on each of the five attributes of autobiographical memory are presented for each of the three groups in Table 2. Although the WAS were generally very high (overall $M = 6.62$) analyses revealed significant differences among the three groups, $F(2, 568) = 38.79$, $p < 0.001$, $\eta^2 = 0.96$, with scores lowest for the New York sample. This pattern was consistent for each of the five attributes that composed the WAS.

To assess whether autobiographical memory was significantly related to the degree of self-reported arousal, the correlation was computed between the WAS and degree of distress reported. Computed across all participants, this correlation was not significant, $r = 0.005$, ($N = 567$), nor was the correlation significant within any of the three samples. Although this result may be an artifact of ceiling effects with both measures, a consistent relationship between arousal and memory was also reported by Neisser, et al. (1996) and others.

Table 2. Mean scores (range = 0–2) for each of the five attributes of autobiographical memory and mean weighted attribute scores (range = 0–7) for each group with the significance levels indicated

Attribute	NY	CA	HI	Statistical significance
Location	1.88	1.99	1.98	$F(2, 568) = 14.30$, $p < 0.001$, $\eta^2 = 0.98$
Informant	1.65	1.89	1.95	$F(2, 568) = 33.46$, $p < 0.001$, $\eta^2 = 0.96$
Activity	1.93	1.99	1.99	$F(2, 568) = 4.70$, $p < 0.05$, $\eta^2 = 0.98$
Time	1.81	1.82	1.83	$F(2, 568) = 0.072$, $p = 0.930$
Others Present	1.87	1.97	1.97	$F(2, 568) = 8.09$, $p < 0.001$, $\eta^2 = 0.99$
WAS	6.37	6.83	6.87	$F(2, 568) = 38.79$, $p < 0.001$, $\eta^2 = 0.96$

Table 3. Mean rating per group (range = 0–2) for qualities indicated in open-ended responses to the autobiographical memory question with the significance levels indicated

	NY	CA	HI	Statistical significance
First thing said to you	1.67	1.9	1.8	$F(2,568) = 11.61$, $p < 0.001$, $\eta^2 = 0.91$
First thing you said	1.8	1.95	1.87	$F(2,568) = 5.03$, $p < 0.01$, $\eta^2 = 0.82$
Disbelief expressed?	0.39	0.22	0.42	$F(2,568) = 6.20$, $p < 0.01$, $\eta^2 = 0.85$
Emotion expressed?	0.59	0.36	0.46	$F(2,568) = 5.07$, $p < 0.01$, $\eta^2 = 0.83$
Go about your day?	1.44	0.84	0.72	$F(2,568) = 52.66$, $p < 0.001$, $\eta^2 = 0.97$

In addition to the WAS, responses were also coded from 0 (no information provided) to 2 (specific information provided) for (a) memory for the first thing said to you, and (b) memory for the first thing that you said. The mean ratings per group, with the significance level for each indicated, are reported in Table 3. Significant differences resulted across the three groups on both items, with memory less detailed for New Yorkers. These results are consistent with the finding that autobiographical memories were generally less specifically detailed in the New York sample.

Constructive memory questions

The final set of analyses assessed the extent to which memory for the events of September 11 was subject to constructive memory distortions. Question 4 was, 'On September 11, did you see the videotape on television of the first plane striking the first tower?' In fact, the video recording of the first plane striking the first tower was not broadcast until September 12. Thus, responses to this question assess the extent to which there were constructive memory distortions regarding this event. That is, the first plane striking the first tower was the first event in the sequence of terrorists' events that occurred, and most participants did see the televised segment of this event. Therefore, in reconstructing their memory they retained memory for the televised segment presenting this event as having occurred first, that is, on September 11.

Across the three samples, 73% of the respondents incorrectly reported, 'yes,' that on September 11 they did see the videotape on television of the first plane striking the first tower, and this pattern was evident in all three samples. Further, the mean confidence rating was significantly higher for people who incorrectly reported 'yes' (overall $M = 6.55$, $SD = 1.12$) than to those who correctly reported 'no' to question 4 (overall $M = 5.53$, $SD = 1.70$), $t\ (555) = 8.13$, $p < 0.001$. Question 4 was the only question for which the correlation between accuracy and confidence was significant and negative, $r = -0.33$, ($N = 557$), $p < 0.01$. Even among the New York participants, the majority (76%) incorrectly responded 'yes' to question 4, and those who incorrectly responded 'yes' were significantly more confident ($M = 6.59$) than those who correctly responded 'no' ($M = 5.48$), $t\ (267) = 5.82$, $p < 0.001$. It is also interesting to note that the correlation between accuracy on this question and the amount of television watched on September 11 was not significant, $r = -0.05$, ($N = 526$); the effect is thus not simply a consequence of the amount of media exposure to the event.

The responses to question 5, 'Was the Pentagon struck before the first tower collapsed?' also evidence constructive distortion of memory for the events of September 11. Only 61% of the participants responded correctly, 'yes,' and the pattern of responding did not differ across groups, $X^2(2) = 1.58$, $p = 4.54$. The North Tower was struck at 8:45 and it began to

collapse at 10:28. The Pentagon was struck at 9:41, before either tower began to collapse. One explanation for the low accuracy rate on this question (given the chance accuracy rate of 50%) is that the participants experienced the attack on New York first and consequently, the events in New York were clustered in memory and reconstructed as having occurred prior to the attack on the Pentagon. This interpretation is supported by the finding that accuracy on this question was significantly negatively correlated with the mean time that the participants first heard of the terrorists' attack after the first World Trade Center tower had been struck, $r = -0.17$, ($N = 509$), $p < 0.01$. Thus, participants who first heard of the events later, were less likely to correctly sequence the events in memory.

DISCUSSION

This research extends the findings of other studies of memory for stressful events and specifically compares event memory and autobiographical memory for an event experienced to be more distressing than was perhaps any other event for which memory has been studied in a large sample of participants. The major finding is that whereas event memory was most accurate in the New York sample that was most directly affected and the most distressed by the events of September 11, autobiographical memory was least accurately reported in this sample. The discussion focuses first, on an interpretation of this finding and second, on patterns of errors that occurred in event memory.

Event memory and autobiographical memory

The narrative hypothesis of Neisser, et al. (1996) is the leading interpretation of the finding that people more involved in a stressful event remember their experience of the event better than people less involved in the event. According to the narrative hypothesis, emotionally charged events are more likely to be transferred into narrative constructions and frequently rehearsed as such. It is this repeated rehearsal that leads to better memory for the events. The results of this study suggest that this conclusion is too simple and this study tests an extension of this interpretation.

It is proposed that an emotionally charged stressful event and people's experience of it are perceived and processed separately, resulting in separate memories. Accordingly, the emotions produced by the event could be attached to the external event or to one's personal experience of the event, and whichever of these two is more vivid will be associated in memory with relatively more of the emotions. Because more vivid emotional information is more readily available in memory and more likely to be rehearsed, it is the more vivid and emotionally arousing aspect of the experience—either the event memory or the autobiographical memory—that will receive relatively more narrative rehearsal and be more accurately retained.

It was hypothesized that for the New York participants, who were more personally involved in and more distressed by the terrorists' attack, the events that transpired were monitored more carefully because these events more directly and more immediately threatened them. Thus, relatively more of the emotionality of the situation was likely to be attached to their memory for the events than to their memory for their personal experiences. Consequently, their event memory was predicted to receive more narrative rehearsal and be high, and their autobiographical memory was predicted to be low relative to the other two groups. On the other hand, for the California and Hawaii participants who

were less personally involved and less distressed by the terrorists' attack, relatively more of the emotionality was likely to be attached to their autobiographical memory than to their event memory, and it is their autobiographical memory that would have received more narrative rehearsal. Consequently, for these participants, event memory was predicted to be low and autobiographical memory was predicted to be high relative to the New York sample. These hypotheses were confirmed in this study. Whereas event memory (as reflected in the responses to questions 6–10 in Table 1) was most accurate in the New York sample that was most directly involved in and most distressed by the events of September 11, autobiographical memory (as reflected in the results reported in Tables 2 and 3) was reported in less detail by this sample.

What mechanisms might account for the attachment of emotionality to autobiographical or event information? Using a different paradigm, MacKay et al. (in press) reported that when taboo words (referring to profanity or obscenity) are presented in a taboo Stroop task, longer color-naming resulted for taboo than for neutral words. However, on a subsequent unexpected memory test, participants recalled more of the taboo words than the neutral words and more accurately recognized the color that taboo words had consistently been presented in than the color of neutral words. Based on these findings, MacKay et al. (in press) hypothesized that emotional reactions automatically activate binding mechanisms that serve to link the source of the emotion to its context-of-occurrence.

Generalizing to the present study, these automatically activated binding mechanisms would come into play during highly stressful events such as while experiencing the events of September 11, and would bind the emotionality of the event to the more salient context-of-occurrence, either the autobiographical context or the context of the external event, whichever is more salient. This model makes other specific predictions regarding memory for stressful events. In their fourth experiment, MacKay et al. (in press) reported that the binding processes for taboo words impeded the rapid encoding of neutral words immediately prior to and subsequent to the taboo words. If this model does, in fact, account for the results in the present study, future research on memory for highly stressful events might test whether the automatic binding mechanisms activated by highly emotional reactions, strengthen the encoding of the emotional event but impede the encoding of the previous and subsequent events.

What type of narrative rehearsal occurred for the events of September 11? A remarkable observation in the open-ended responses to question 1 was the finding that the large majority of the participants sought out social contact upon first hearing of the terrorists' attack, and the social contact extended well beyond the individuals in their immediate environment. The responses revealed that students, especially in the New York sample, spent much of September 11 phoning friends and relatives for updates on what had transpired and to see if they were all right. The outage of the cell phone service in New York caused by the collapse of the World Trade Centers was reported to be extremely upsetting to the New Yorkers. Similarly, students in California and Hawaii were on the phone with parents, other family members and friends, as if needing to be reassured that some aspect of life was secure and normal. The process of talking about the terrorists' attack seemed to serve to make the events more comprehensible by providing a coherent narrative. According to Neisser, et al. (1996), it was this narrative rehearsal, both immediately following an event and in the subsequent weeks, shapes event memory.

This study is a quasi-experimental design in which participants were not randomly assigned to levels of the independent variable—geographic location. Accordingly, although these results suggest an interesting and more complex relationship between

narrative rehearsal and memory, the findings should be treated with caution as there are several alternative explanations of the obtained results. The three geographic groups were selected because they were hypothesized to differ in the level of distress experienced and level of involvement in the events of September 11, and they did. However, the differences among the geographic groups could also have resulted from, for example, sampling differences as well as from differences in the quantity and quality of information received, knowledge about New York City, the local consequentiality of the events, the time of day at which participants first learned of the events, and the extent to which there were daily reminders of the events, especially in New York. Certainly additional research is necessary to exclude these alternative interpretations of the results. So too were there differences between the measures of autobiographical memory and event memory in this study; the event memory questions were more specific than the autobiographical memory questions, and it was possible to verify the veracity of event memory but not autobiographical memory answers. Opportunities should be tapped for studying events for which more comparable measures of event memory and autobiographical memory are available.

Keep in mind that in this study, the terrorists' attack on September 11 was experienced to be highly distressing to participants in all three samples; across the three groups, the mean response to the question assessing self-reported level of distress was 5.25 ($SD = 1.47$) on a 7-point scale. In addition, autobiographical memory was recalled with a high level of detail; the mean WAS across the three groups was 6.62, $SD = 0.69$ (range = 0–7). And, except for questions 4 and 5, event memory was quite accurate as well. By comparison, the mean emotionality rating by the California participants in the Neisser, et al. (1996) study of memory for the Loma Prieta earthquake was about 4, the middle of a 7-point scale, and the mean WAS reported by Neisser and Harsch (1992) in the study of memory for the Challenger disaster was about 3 (range = 0–7). The terrorists' attack on September 11 was, in fact, more distressing than were the events focused on in other studies of 'flashbulb memory.' Nonetheless, even in the New York sample in the present study, autobiographical memory and event memory were quite accurately retained. However, errors in event memory did occur, and they followed predictable patterns.

Patterns of errors in event memory

This study afforded the opportunity to test if memory for a salient stressful event is subjected to the same type of distortions that everyday memories suffer from. This issue has important implications to eyewitness memory research and the veracity of witnesses' accounts of stressful events. In a recent review of the literature, Pezdek and Taylor (2002) reported that many characteristics of memory for nontraumatic events apply to memory for traumatic events as well. Responses to two questions in this study are relevant here. First, 73% of the participants incorrectly reported, 'yes,' that on September 11 they did see the videotape on television of the first plane striking the first tower, and the mean confidence rating was significantly higher for people who incorrectly reported 'yes' than to those who correctly reported 'no'. This finding is consistent with reports by Ost, Vrij, Costall, and Bull (2002) that 45% of their United Kingdom sample reported that they had seen a (non-existing) film of the car crash in which Diana, Princess of Wales was killed.

Second, only 61% of the participants correctly reported, 'yes,' that the Pentagon was struck before the first tower collapsed. One interpretation of this low accuracy rate (in light of a chance rate of 50%) is that the events in New York were clustered in memory and reconstructed as having occurred first. Together, these findings suggest that memory for

some aspects of the events of September 11 exhibited constructed memory distortions rather than being retained veridically as they had in fact occurred.

Memory for the temporal duration of the events of September 11 also evidence constructive distortions. Participants' mean estimate of the duration from when the first tower was struck to when it collapsed was 62 minutes, substantially less than the correct response (108 min), and responses did not differ across groups. Several researchers have reported that witnesses' estimates of the duration of a stressful event tend to be exaggerated (Buckhout, 1974; Loftus, Schooler, Boone, & Kline, 1987), but the target events in these other studies were experienced in real time. In contrast, few participants experienced the events of September 11 in real time. The current finding of compressed memory for the events of September 11 may simply reflect that the events were retained as they were perceived (primarily on television) rather than as they occurred.

Together, these findings are likely to generalize to eyewitness memory. If relatively more of the emotions produced by a stressful event are attached to a witness's autobiographical experience, then memory for this aspect of an event is more likely to be rehearsed and will be better retained in memory. On the other hand, if relatively more of the emotions produced by an event are attached to a witness's experience of the event itself, then details of the event itself are more likely to be rehearsed and will be better retained. Future research is necessary to understand the conditions under which relatively more of the emotions produced by an event become attached to memory for the event itself versus the autobiographical memory.

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