
MEMORIES OF AN EMOTIONAL AND A NONEMOTIONAL EVENT: EFFECTS OF AGING AND DELAY INTERVAL

Elizabeth A. Kensinger

Department of Brain and Cognitive Sciences, Massachusetts Institute of
Technology, Cambridge, Massachusetts, USA; Athinoula A. Martinos
Center for Biomedical Imaging, Charlestown, Massachusetts, USA; and
Department of Psychology, Harvard University, Cambridge,
Massachusetts, USA

Anne C. Krendl

Department of Brain and Cognitive Sciences, Massachusetts Institute of
Technology, Cambridge, Massachusetts, USA

Suzanne Corkin

Massachusetts Institute of Technology, Department of Brain and Cognitive
Sciences, Cambridge, Massachusetts, USA; Athinoula A. Martinos
Center for Biomedical Imaging, Charlestown, Massachusetts, USA

The present study compared the memory of young and older adults for details pertaining to two public events of close temporal proximity but varying emotional import—the Columbia shuttle explosion and the 2003 Super Bowl. Participants responded to surveys sent within 2 weeks of these events and then again 7 months later, providing information about event-related details (i.e., of the events themselves) and personal

Received 12 January 2005; accepted 14 April 2005.

This research was supported by NIH grant AG021525, and a Howard Hughes Medical Institute Predoctoral Fellowship (to E.A.K.). E.A.K. is now supported by NIH grant MH070199.

Address correspondence to Elizabeth A. Kensinger, 33 Kirkland Street no. 884, Cambridge, MA 02138, USA. E-mail: ekensing@wjh.harvard.edu

details (i.e., of the reception event). Both age groups rated the shuttle tragedy as significantly more emotional than the Super Bowl, and although older adults often had poorer memory overall, both age groups remembered more about the shuttle than they did about the Super Bowl. Further, the age discrepancy (young adults remembering more than older adults) was less pronounced for the shuttle than for the Super Bowl. Thus, older adults' memories appear to benefit from the emotional salience of real-life events.

Memory often is better for emotional events than for events lacking emotional relevance. This emotional memory enhancement effect has been demonstrated in a wide range of laboratory studies, using a variety of verbal and nonverbal stimuli (reviewed by Hamann, 2001; Buchanan & Adolphs, 2002). The effect of emotional salience on memory extends to investigations of autobiographical memory: Individuals tend to remember more information surrounding an emotional event than surrounding a nonemotional one. At an extreme are "flashbulb memories" (FBM), for which individuals retain a vivid and detailed recollection of the event, even long after the event's occurrence (Brown & Kulik, 1977). The hallmark of FBM is that individuals remember the details of the *reception event*: What they were doing, wearing, etc., when they first heard of the event. For example, nearly everyone who was over the age of 7 at the time claims to remember their whereabouts when they learned that John F. Kennedy (J.F.K.) had been assassinated (Winograd & Killinger, 1983).

It remains unclear what effect healthy aging has on the ability to remember emotional events. On the one hand, laboratory evidence indicates that older adults can benefit from the emotional relevance of information to boost their memories (Denburg, Buchanan, Tranel, & Adolphs, 2003; Kensinger, Anderson, Growdon, & Corkin, 2004; Kensinger, Brierley, Medford, Growdon, & Corkin, 2002; Kensinger, Piguet, Krendl, & Corkin, 2005) and to reduce the likelihood of memory distortion (Kensinger & Corkin, 2004). Other studies, however, report blunted emotional enhancement effects for older as compared to young adults, particularly for negative stimuli (Charles, Mather, & Carstensen, 2003). It is plausible that the contradictory results were due to differential arousal elicited by the stimuli (Krendl, Kensinger, & Corkin, 2003) or to differences in the delay after which memory was assessed.

The data with regard to FBM are similarly mixed. One of the early studies examining the effect of age on FBM (for the assassination of J.F.K.) found no relation between age and the likelihood of flashbulb memory retention (Christianson, 1989), whereas another found that

adults who were young in 1963 were more likely than older adults to retain details of the event (Yarmey & Bull, 1978).

More recent studies have been met with similarly opposing findings. For example, in assessing the effects of age on the formation of FBM for the resignation of Margaret Thatcher, the Prime Minister of Great Britain, Cohen, Conway, and Maylor (1994) found markedly impaired FBM among older adults as compared to young adults: Only 42% of older adults formed FBM compared to 90% of young adults. Tekcan and Peynircioglu (2002) also reported lower rates of FBM for older (72%) than young (90%) adults for the death of the 8th president of Turkey. Wright, Gaskell, and O'Muirheartaigh (1998), however, found that three years after the resignation of Margaret Thatcher, a *larger* proportion of older adults compared to young adults reported recalling personal details surrounding the announcement of Thatcher's resignation, and Otani et al. (2005) recently reported similar rates of FBM in young and older adults for a nuclear accident in Japan.

Any number of methodological factors could account for these contrary results. Wright et al. (1998) assessed memory via a marketing phone interview, in which participants simply responded 'yes' or 'no' to questions, whereas Cohen et al. (1994) and Tekcan and Peynircioglu (2002) used written responses to a questionnaire. In addition, the definition of FBM differed among the studies: Cohen et al. (1994) and Otani et al. (2005) defined FBM as consistency over time, whereas Tekcan and Peynircioglu (2002) and Wright et al. (1998) defined FBM as the ability to remember information after a delay. Further, the delay after which memory was probed ranged from 11 months in Cohen et al. to 3 years in Wright et al. and Tekcan and Peynircioglu.

An important limitation of all of these studies is that they did not include a control event. Thus, it remains unclear whether the findings reflect general age differences (or lack thereof) in memory formation, or whether they speak specifically to the ability of older adults to form memories about emotional events. Tekcan and Peynircioglu (2002) found that older adults were able to retrieve more information about emotional events than nonemotional ones that occurred when they were young adults. Thus, this result suggests that aging does not eliminate the memory enhancement for retrieval of emotional events. Their study could not include a young adult control group, however (because the event had occurred 50 years earlier), and thus their study left unanswered whether the emotional memory enhancement in the older adults was comparable to that of young adults. To our knowledge, only one study examining FBM formation for the same events in young and older adults included a nonemotional control

event: Davidson and Glisky (2002) asked participants about the deaths of Princess Diana and Mother Theresa, and about an event from Labor Day weekend. They found no age effects in the frequency of FBM formation, and after a delay, both age groups recalled more information about the two emotional events than about the nonemotional control event.

The present study examined young and older adults' memories for the Columbia shuttle explosion on February 1, 2003. The close proximity of this event to Super Bowl XXXVII on January 26, 2003, provided an opportunity to assess memory for two discrete public events that differed in emotional content. The goal of the present study was to examine whether age would differentially affect the ability to recall details from a highly emotional as compared to a less emotional event, after a short (2-week) and long (7-month) delay. We also examined whether the emotional importance of the event would differentially impact memory for *event details* and *personal details* in the young and older adults. A recent study (Pezdek, 2003) has suggested that the aspects of an event most closely tied to the emotional response (either those of the event itself, or those of the reception event) will be those better remembered. For example, in FBM assessments of the terrorist attacks on September 11, 2001, those individuals most directly involved in the event (those living in New York) retained more event details than autobiographical details, whereas those less personally involved in the events (those living in California or Hawaii) retained more autobiographical than event details (Pezdek, 2003; see also Smith, Bibi, & Sheard, 2003, and Tekcan et al., 2003, for supporting evidence from memory assessments of individuals living in Canada and Turkey, respectively). The design of the present study allowed comparison of memory for *event details* and *personal details* in young and older adults.

METHODS

Participants

For the present experiment, 62 older adults (mean age 72.6, $SD = 7.0$) and 48 young adults (mean age 24.8, $SD = 4.3$) completed a survey on the Columbia shuttle tragedy within two weeks of February 1, 2003. Seven months later, the same survey was sent to the same group of participants, and 40 (64.5%) older adults and 17 (35.4%) young adults responded within 3 weeks of the survey mailing.¹ Young adults were

¹The demographics of the individuals who responded were comparable to those of the nonresponders.

Massachusetts Institute of Technology (MIT) undergraduate or graduate students. Older adults were healthy individuals enrolled in cognitive and neuroimaging studies at MIT. All participants were screened for the presence of depression, neurological and cardiovascular diseases, and no adult took medication impacting cognitive functioning or alertness. This study was reviewed and approved by the MIT Committee on the Use of Humans as Experimental Subjects.

Materials and Procedure

Identical surveys were sent out at Time 1 and Time 2. Each consisted of 20 questions about the shuttle tragedy, and 20 parallel questions about the Super Bowl. The survey questions were divided into three categories: event-related details, personal details, and assessments of surprise, importance, and rehearsal (see Appendix 1). The event-related details for the shuttle centered on public details about the shuttle and the incident (e.g., What was the name of the shuttle? At what time was the shuttle lost? How many people were aboard the shuttle?). Personal details about the shuttle tragedy focused on the reception event surrounding the Columbia shuttle explosion (e.g., Where were you when you learned the news? Who were you with?). Questions regarding the Super Bowl were designed to parallel those asked about the shuttle (Event-related details: What was the name of the team that won the game? What time did the game start?; Personal details: Where did you watch the game? Who were you with?). We also asked participants to rate how important and surprising they found the events, and to provide information regarding their rehearsal of the event (how long they had spent watching media coverage, talking about the event, or thinking about the event).

Survey Scoring

Survey scores for Time 1 and Time 2 were based on how many pieces of accurate information the participants provided. We scored answers to each question separately, and then we tallied the total number of points for a particular detail type for an event (e.g., event-related details for the shuttle event to compute a “composite score”).

Scoring of Event-Related Details

The event-related details were scored by one of the authors (ACK). With two exceptions, the questions were scored by giving 1 point for every piece of information that was fully recalled, 1/2 point to partially recalled or vague but correct information, and 0 points to

inaccurate or skipped responses. The two exceptions were for the *time* of the events and the *names* of the shuttle and Super Bowl winner. These questions were scored in a binary fashion (1 if correct, 0 if incorrect) to avoid point allotment based on guessing or semantic knowledge (e.g., someone responding that the Super Bowl occurred “in the evening”). Below we outline the specific scoring system used for the event-related details of the shuttle and Super Bowl.

For the shuttle name, 1 point was given for the correct answer Columbia; other answers received 0 points. For the time, 1 point was given if the participant responded that the disaster happened between 8:00 and 10:00 AM (the disaster happened at 8:16 AM CT/9:16 AM EST); any other answers received 0 points. For the number of people on board the shuttle, 1 point was awarded for the correct answer 7, and 1/2 point was awarded for any other answer between 6 and 9. For information about the crew members, 1 point was given for each specific piece of information (i.e., the names of a crew member, a clear identifier such as “Israeli pilot” or “woman from India”) and 1/2 point was awarded for less specific information recalled (i.e., “a woman was on board” or “a Jewish man”). For details about the event itself, a full point was awarded for each concrete piece of information provided (i.e., a mention of the “white vapor trail” seen in the sky after the explosion), 1/2 point was given for accurate but less detailed information recalled, and 0 points were given if no response was provided or if the response was generic and vague (e.g., “an image of the shuttle”). Although we had asked about the place where the shuttle was lost, we do not report data from this question because the question’s wording led some individuals to give a vague answer (e.g., “in space”) that, although correct, did not allow us to assess whether they knew more specifically where the shuttle disaster occurred (e.g., “over Texas”). Points awarded for all other questions were tallied to compute the “composite score” for the shuttle’s event-related details.

For the name of the Super Bowl champion, we gave 1 point for the answer Tampa Bay, the Buccaneers, or any combination therein; other answers received 0 points. For the time, we gave 1 point if the participant reported that the game started between 5:00 and 7:00 PM (kickoff was at 6:25 PM EST); other answers received 0 points. For people, we gave 1 point for each correct response. For event details, a full point was awarded for each concrete piece of information provided (i.e., for each particular play mentioned, for specific songs played at half-time, etc). We then tallied these scores to create the “composite score” for the Super Bowl’s event-related details (because we were not able to score the place for the shuttle event,

responses to the Super Bowl's place were not included in the composite scores).

Scoring of Personal Details

A similar system was used to score the personal details: 1 point was given for each specific piece of information recalled (e.g., "My husband came into the kitchen and told me about the shuttle"; "I watched the Super Bowl with my son-in-law at home"; or "I was wearing a green pants suit"), and 1/2 point was given to partially recalled or somewhat vague information (e.g., "Someone told me the shuttle had gone down"; or "I wore pants and a shirt that day."). No points were given for responses that appeared to be based on semantic knowledge (e.g., "I must have worn khaki pants that day because I always do"), for sufficiently vague responses as to show no indication of episodic memory (e.g., "I was wearing clothes"), or for skipped responses. Because scoring of personal details was more subjective than scoring of event-related details, the personal details were scored by two MIT undergraduates who were blind to the age of the participants and the delay conditions. The two scores were averaged to yield the final score that was used in subsequent analyses. Interrater reliability for these scores was high (Pearson $r > .90$ and Cronbach's alpha $> .95$ for both the shuttle event and the Super Bowl).

Scoring for Consistency Analyses

To examine the consistency of responses over time, 1 point was assigned to all responses that were identical at Time 1 and Time 2, 1/2 point was assigned when information was slightly distorted between Time 1 and Time 2 (e.g., Time 1: "I was wearing a red sweatshirt, black pants, and flip-flops," Time 2: "I was wearing a red sweatshirt, black pants, and sneakers") or if only partial information was reported at Time 2 (e.g., "I was wearing a red sweatshirt") and 0 points if the answer was different (e.g., "I was wearing jeans and a t-shirt").

Assessments of Importance, Surprise, and Rehearsal

Participants were given a 10-point scale to rate how important the shuttle tragedy was (1 = had little effect on me, 10 = continues to have a major effect on me), and a 6-point scale to rate how surprising they found the event to be (1 = was not at all surprising, 6 = was incredibly surprising). For estimates of rehearsal time, we gave participants 0 points if they responded that they had not thought or talked about the events at all, 0.5 points if they responded that they had thought or talked about the events "a little bit," "some right after it occurred" (or a comparable answer), and 1 point if they

responded that they had thought or talked about the event “a lot,” “most days,” “many hours” (or a comparable answer). Participants were asked to make similar ratings for the Super Bowl, (i.e., how important and surprising they found the event to be, and how much time they had spend thinking or talking about the event).

Differences between the Events

When comparing memory for real-life events, it is impossible to obtain the same level of control regarding the events’ characteristics as can be achieved in the laboratory. Some features of the Columbia shuttle explosion and Super Bowl made them ideal events to compare in order to examine the effects of emotion on memory: The two events were both public events that occurred in close proximity to one another, yet they differed significantly in the magnitude of their emotional importance. There were features aside from emotional importance, however, that differed between the events; these factors may also have influenced memory performance. For one, although both events attracted significant media attention, the type of coverage was different. For the Super Bowl, most coverage was before the game, and coverage following the game would not have included details such as the day or time of the event. In contrast, for the shuttle explosion, all coverage followed the event, and details such as the day and time of the event were repeated frequently. Second, the Super Bowl was an event extended in time whereas the shuttle explosion took place over a very brief period of time. Thus, memory for the personal details of the reception events have different temporal characteristics (e.g., memory for location must be circumscribed to a narrow time window for the shuttle event but not for the Super Bowl). Third, the Super Bowl was an expected and anticipated event whereas the Columbia shuttle explosion was a surprise. Thus, some of the information reported about the Super Bowl (e.g., day, time) may have been due to semantic rather than episodic knowledge, and some of the personal details remembered (e.g., who a person was with while watching the game) may have been remembered from the planning that had preceded the event (e.g., remembering calling friends to organize a get together) rather than from an episodic memory of the event itself.

RESULTS

We first analyzed results separately for event-related details and for personal details. For each of these detail types, analyses of variance

(ANOVAs) were conducted with event (shuttle, Super Bowl) and delay (Time 1, Time 2) as within-subject factors and age and sex as between-subject factors.

Event-Related Details of the Shuttle Tragedy and the Super Bowl

We first computed composite scores for all of the event-related details recalled about the shuttle and about the Super Bowl (see scoring section of Methods). Although there was no specified upper limit on these values (e.g., a person could be awarded an unspecified number of points for the question “What additional information do you remember about the event?”), as Tables 1 and 2 show, the maximum number of points obtained was 10.

An ANOVA conducted on these composite scores revealed main effects of delay (Time 1 > Time 2; $F(1, 56) = 46.0, p < .001$, partial eta-squared = .23) and age (young > older; $F(1, 56) = 35.2, p < .01$, partial eta-squared = .19), as well as an interaction between event and age ($F(1, 56) = 6.33, p < .013$, partial eta-squared = .04). The interaction reflected the fact that older adults were disproportionately impaired (relative to young adults) at remembering details about the Super Bowl than about the shuttle (Tables 1 and 2).

There also were effects of sex: Men tended to remember more about the Super Bowl than the women (ANOVA indicated an interaction between event and sex, $F(1, 56) = 9.15, p < .01$, partial eta-squared = .07) and to forget less about the Super Bowl over time than the women (ANOVA indicated a three-way interaction between event, delay, and sex, $F(1, 56) = 4.03, p < .05$, partial eta-squared = .03). There was no three-way interaction between event, age, and sex and no four-way interaction between event, age, delay, and sex (partial eta-squared = .00). Thus, the influence of sex on memory

Table 1. Columbia shuttle explosion: Event-related details (mean number of points, *SD*) recalled

	Young adults		Older adults	
	Delay 1	Delay 2	Delay 1	Delay 2
Name (max. possible = 1)	.96 (.20)	.82 (.39)	.81 (.40)	.51 (.50)
Time (max. possible = 1)	.83 (.33)	.59 (.40)	.78 (.37)	.45 (.42)
Event details composite score (max. obtained = 10)	4.60 (2.45)	2.71 (1.16)	2.26 (1.51)	1.88 (1.44)

Table 2. Super Bowl: Event-related details (mean, SD) recalled

	Young adults		Older adults	
	Delay 1	Delay 2	Delay 1	Delay 2
Name (max. possible = 1)	.70 (.45)	.29 (.47)	.64 (.58)	.13 (.34)
Time (max. possible = 1)	.41 (.49)	.50 (.46)	.44 (.47)	.29 (.45)
Event details composite score (max. obtained = 10)	5.57 (3.29)	2.43 (1.81)	2.36 (2.25)	.86 (1.61)

for the event-related details of the shuttle and Super Bowl was comparable for the young and older adults. Critically, the interaction between event and age discussed above was not affected by the sex of the participants.

We also conducted separate analyses of two elements that had been included in this composite: the name of the shuttle versus the name of the Super Bowl winner (Tables 1 and 2), and the time of the events.

Name of Shuttle versus Name of Super Bowl Winner

For the names, an ANOVA indicated a main effects of event (shuttle > Super Bowl; $F(1, 56) = 42.4, p < .001$, partial eta-squared = .22) and delay (Time 1 > Time 2; $F(1, 56) = 32.1, p < .001$, partial eta-squared = .18), and a marginal effect of age (young > older; $F(1, 56) = 12.5, p < .001$, partial eta-squared = .08). Interestingly, part of the effect of age may have resulted from name interference among the older adults: Nearly 20% of older adults incorrectly identified the name of the shuttle as the Challenger at Time 2, whereas none of the young adults did. The ANOVA also revealed an interaction between event and delay ($F(1, 56) = 6.6, p < .05$, partial eta-squared = .04), with delay impacting memory for the name of the Super Bowl winner more than the name of the shuttle. This effect was more pronounced for women than for men (ANOVA indicated an interaction between event, delay, and sex, $F(1, 56) = 4.92, p < .05$, partial eta-squared = .04). Importantly, there were no interactions with age; thus the effects of event type, delay, and sex were comparable for the young and older adults.

Time

For the time of the events, an ANOVA revealed a main effect of event (shuttle > Super Bowl, $F(1, 56) = 21.3, p < .001$, partial eta-squared = .12) and delay (Time 1 > Time 2, $F(1, 56) = 9.0, p < .01$, partial eta-squared = .06), a marginal effect of age (young > older,

$F(1, 56) = 3.6, p < .07$, partial eta-squared = .03), and an interaction between event and delay (effect of delay greater for the Super Bowl than for the shuttle; $F(1, 56) = 5.5, p < .05$, partial eta-squared = .04). There was a trend for the effect of event to be less pronounced in men than women (ANOVA indicated a marginal three-way interaction between event, delay, and sex, $F(1, 56) = 2.99, p < .09$, partial eta-squared = .03), because the men were more likely than the women to remember the start time of the Super Bowl. Importantly, there were no interactions with age. Thus, the influences of event, delay, and sex on memory for the time of the events were comparable in young and older adults.

Event-Related Details Unique to the Shuttle Tragedy

A few additional variables (aside from time, name, and event details) were not comparable across the two events, but were analyzed to examine the effects of age and delay on memory. For the shuttle, remaining aspects that we assessed were: number of people on board and details about people on board (Table 1). For each, we conducted an ANOVA to examine the effect of delay and age on memory performance.

Number of People

An ANOVA indicated a main effect of delay (Time 1 > Time 2, $F(1, 56) = 26.43, p < .001$, partial eta-squared = .14) and age (young > older, $F(1, 56) = 6.33, p < .01$, partial eta-squared = .04), and an interaction between delay and age ($F(1, 56) = 7.01, p < .009$, partial eta-squared = .04). The interaction emerged because older adults were more likely than the young adults to forget the number of people on board the shuttle over time. There were no interactions with sex (all partial eta-squared < .01), indicating that these effects of delay and age were comparable in men and women.

Details about People

An ANOVA revealed only a main effect of age ($F(1, 56) = 8.11, p < .01$, partial eta-squared = .05), with the older adults remembering significantly less than the young adults about the people on board the shuttle. This effect of age was comparable in men and women: There was no significant interaction between age and sex (partial eta-squared < .01).

Personal Details Related to the Shuttle Tragedy and the Super Bowl

To examine memory for personal details, we created composite scores for all of the personal information recalled about the shuttle and the Super Bowl (see description of scoring system in Methods). As with

Table 3. Composite scores for personal details (mean, *SD*) recalled about the Columbia shuttle and Super Bowl events

	Young adults		Older adults	
	Delay 1	Delay 2	Delay 1	Delay 2
Shuttle (max. obtained = 14)	6.47 (3.11)	5.47 (3.15)	4.55 (2.18)	2.57 (2.09)
Super Bowl (max. obtained = 10)	3.81 (2.18)	3.3 (2.33)	3.16 (2.55)	1.39 (1.47)

the event-related composite scores, there was no specified upper limit on these scores; as shown in Table 3, the maximum score obtained was 14 points.

An ANOVA conducted on these scores revealed a main effect of event (shuttle > Super Bowl; $F(1, 56) = 35.2$, $p < .001$, partial eta-squared = .2), delay (Time 1 > Time 2; $F(1, 56) = 41.2$, $p < .001$, partial eta-squared = .22), and age (young > older; $F(1, 56) = 16.0$, $p < .001$, partial eta-squared = .1). In addition, we found an interaction between event and age ($F(1, 56) = 3.82$, $p < .03$), reflecting a greater age-related discrepancy (young > older adults) for details remembered about the Super Bowl than about the shuttle. Importantly, a large proportion of young and older adults were able to remember a number of personal details surrounding the shuttle event even following the 7-month delay, the hallmark of a FBM (Figure 1).

There also were effects of sex: Men were more likely than women to remember information about the Super Bowl, whereas women were more likely than men to remember information about the shuttle event (ANOVA indicated an interaction between event and sex, $F(1, 56) = 3.94$, $p < .05$, partial eta-squared = .03). Importantly, there was no interaction including age and sex. Thus, the effects of age on memory were not influenced by the sex of the participant.

When personal details recalled were examined for the shuttle and Super Bowl separately, an ANOVA for the shuttle revealed a main effect of delay (Time 1 > Time 2; $F(1, 56) = 10.53$, $p < .001$, partial eta-squared = .06) and age (young > older; $F(1, 56) = 27.57$, $p < .000$, partial eta-squared = .149), but no interaction (Table 3). There was a marginal effect of sex ($F(1, 56) = 3.25$, $p < .08$, partial eta-squared = .02), with women remembering more personal details than the men. There were no interactions with sex (all partial eta-squared < .01), suggesting that the effects of delay and age on memory for personal details surrounding the shuttle were comparable for men and women.

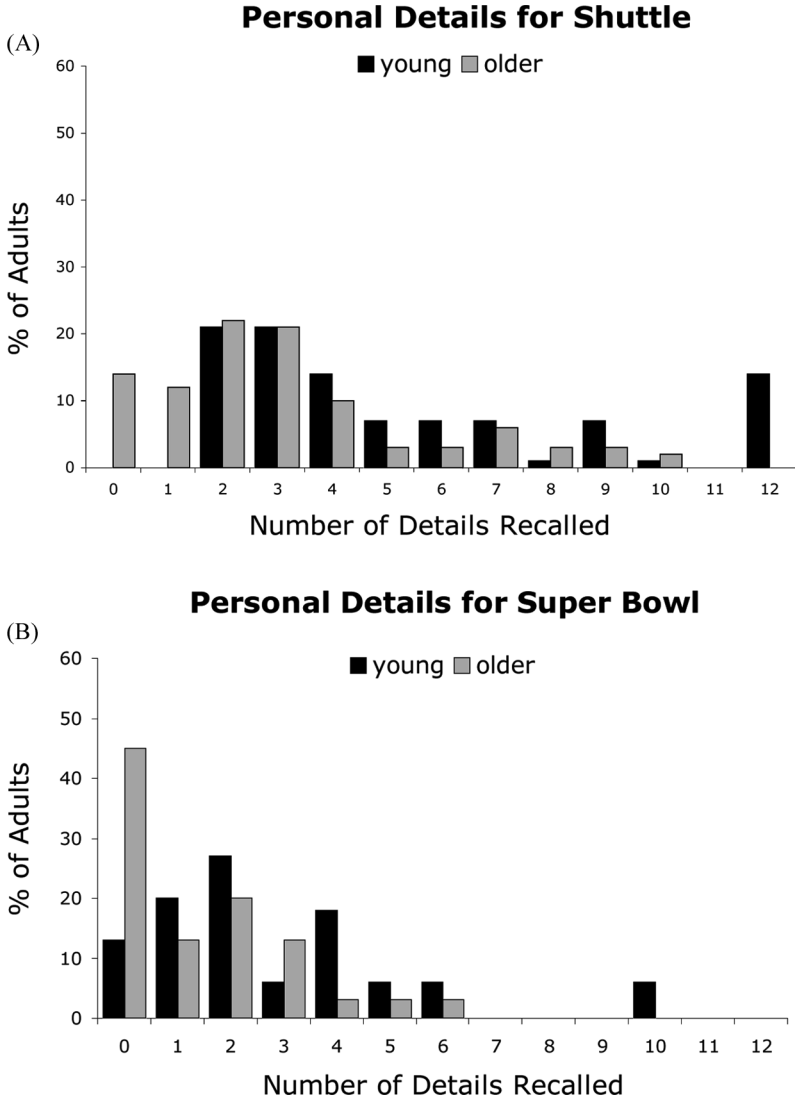


Figure 1. Young and older adults were more likely to remember personal details for the shuttle event (A) than for the Super Bowl (B) when memory was assessed following the 7-month delay. In both age groups, the majority of individuals demonstrated FBM, as reflected by the ability to recall a number of personal details after delay.

Similarly, an ANOVA conducted on the personal details recalled for the Super Bowl indicated an effect of delay (Time 1 > Time 2; $F(1, 56) = 7.86, p < .006$, partial eta-squared = .05), and age (young > older; $F(1, 56) = 9.90, p < .002$, partial eta-squared = .063), but no interaction. There was a marginal effect of sex ($F(1, 56) = 2.79, p < .10$, partial eta-squared = .02), with men remembering more personal details about the Super Bowl than the women, but there were no significant interactions with sex. Thus, the effects of delay and age were of similar magnitude in the men and the women.

To examine more closely the retention of personal details for both events, we analyzed two types of personal details that could be directly compared for the two events: who participants were with, and what the participants were wearing.

Who Participants Were With

Comparing how participants heard about the shuttle tragedy to with whom they watched the Super Bowl, we found a main effect of event ($F(1, 56) = 27.10, p < .001$, partial eta-squared = .17): Memory was significantly better for how participants heard about the Columbia shuttle tragedy than it was for with whom they watched the Super Bowl. An ANOVA also uncovered an event-by-delay interaction ($F(1, 56) = 4.50, p < .036$, partial eta-squared = .033). Both age groups forgot more about the Super Bowl over time than they did about the shuttle. We also found a marginal interaction between event and age ($F(1, 56) = 3.17, p < .08$, partial eta-squared = .023), with older adults showing poorer performance relative to young in remembering with whom they watched the Super Bowl than for how they learned of the shuttle tragedy. The sex of the participants did not influence these interactions (all partial eta-squared < .01).

What They Were Wearing

An ANOVA indicated a main effect of event ($F(1, 56) = 16.56, p < .000$, partial eta-squared = .115), reflecting better memory for clothes worn when learning of the shuttle tragedy than when watching the Super Bowl. Additionally, a three-way interaction was revealed among event, age, and delay: Young adults had a large memory decline over time about what they were wearing on the day of the shuttle tragedy, whereas older adults exhibited a greater memory decline in what they were wearing during the Super Bowl.²

²Although participants were also asked what they ate during the Super Bowl and on the day of the shuttle tragedy, those results were not included in the present report because the judges could not clearly distinguish between semantic knowledge (i.e., "I always eat cereal, so I must have been eating cereal when I heard about the shuttle tragedy") and an actual memory.

The sex of the participants did not influence these interactions (all partial eta-squared < .01).

Consistency Analyses

The analyses discussed so far for personal details considered only the amount of information reported by young and older adults, but not the extent to which information given at Time 2 overlapped with the information given during Time 1. To address the consistency of the personal information recalled, we scored each piece of information at Time 2 on the basis of whether it was identical to that given at Time 1 (1 point), similar but not identical to the information given at Time 1 (0.5 points), or different than the information given at Time 1 (0 points). We then conducted an ANOVA on these consistency scores with event as a within-subject factor and age and sex as between-subject factors. This ANOVA indicated only a main effect of age ($F(1, 56) = 8.21, p < .05$, partial eta-squared = .08), with the young adults showing more consistency in responses (.76 for shuttle, .82 for Super Bowl) than the older adults (.65 for shuttle, .73 for Super Bowl). Importantly, there was no effect of event nor an interaction between event and age. Thus, this effect of age on memory consistency was not influenced by the emotional content of the events.

It should be noted that while this analysis does provide information regarding memory consistency at two time points, it does not necessarily speak to memory accuracy. The initial surveys were not filled out immediately following the event (there was an approximately 2-week delay between the event and the first survey completion); therefore, it is plausible that the information reported at Time 1 reflected a distortion from the personal details experienced.

Comparison of Event-Related and Personal Details

Suggestive evidence in support of Pezdek's hypothesis (Pezdek, 2003), that the emotional salience of the shuttle event may have had a greater effect on memory for the personal details than event-related details came from the fact that there was a main effect of event when the composite scores for personal details were compared, but not when the composite scores for the event-related details were compared. Thus, this finding suggests that the emotional salience of the shuttle event may have had a greater effect on memory for personal details than on memory for event-related details. To more directly examine this hypothesis, and to address whether the effect was comparable in

the young and older adults, we performed an ANOVA on the composite scores with delay (Time 1, Time 2), detail (personal, event-related) and event (shuttle, Super Bowl) as within-subject factors and age and sex as between-subject factors.

This ANOVA revealed main effects of detail (personal > event-related, $F(1, 56) = 10.86, p < .001$, partial eta-squared = .09), event (shuttle > Super Bowl $F(1, 56) = 11.24, p < .001$, partial eta-squared = .09), age (young > older, $F(1, 56) = 23.90, p < .001$, partial eta-squared = .17), and delay (Time 1 > Time 2, $F(1, 56) = 22.66, p < .001$, partial eta-squared = .17). The analysis also uncovered an interaction between event type and delay ($F(1, 56) = 3.9, p < .05$, partial eta-squared = .03) and a three-way interaction among event, age, and delay ($F(1, 56) = 11.4, p < .001$, partial eta-squared = .09). These interactions reflected the fact that memory for the Super Bowl was more affected by the delay than memory for the shuttle, and that this effect was exaggerated in the older adults compared to the young adults.

Critically, the analysis also revealed an interaction between event and detail ($F(1, 56) = 18.58, p < .001$, partial eta-squared = .14), as well as a three-way interaction among event, detail, and age ($F(1, 56) = 9.36, p < .01$, partial eta-squared = .08). These interactions emerged because, as hypothesized by Pezdek (Pezdek, 2003), the emotional content of the event had a greater effect on memory for personal details than on memory for event-related details. This interaction between event and detail was greater in the young adults than in the older adults, however, as reflected by the three-way interaction between event type, detail type, and age (and see Tables 1 and 2).

Assessments of Importance, Surprise, and Rehearsal

We first conducted ANOVAs to examine the effect of event and age on the ratings of importance, surprise, and estimates of rehearsal. For personal importance of the event, an ANOVA indicated a main effect of event (shuttle > Super Bowl; $F(1, 56) = 59.65, p < .001$, partial eta-squared = .24) and an interaction between event and age ($F(1, 56) = 11.04, p < .01$, partial eta-squared = .09). This interaction emerged because young and older adults found the shuttle to be equally important, but young adults rated the Super Bowl as more important than did older adults (Table 4). There also was an interaction between event and sex ($F(1, 56) = 9.03, p < .01$, partial eta-squared = .08), with men finding the Super Bowl of more importance than the women. Importantly, there was no three-way interaction

Table 4. Ratings of importance, surprise, and rehearsal (mean, *SD*) for the Columbia shuttle and Super Bowl events

	Young adults	Older adults
Importance		
Shuttle (max. possible = 10)	5.00 (1.37)	5.85 (2.08)
Super Bowl (max. possible = 10)	3.33 (1.62)	1.67 (1.62)
Surprise		
Shuttle (max. possible = 6)	3.69 (1.07)	3.50 (1.54)
Super Bowl (max. possible = 6)	1.50 (.82)	.95 (.94)
Rehearsal		
Shuttle (max. possible = 1)	.67 (.31)	.72 (.29)
Super Bowl (max. possible = 1)	.30 (.36)	.31 (.32)

between event, sex, and age, indicating that the effects of event and sex were comparable in the young and older adults.

For ratings of surprise, an ANOVA revealed a main effect of event (shuttle > Super Bowl; $F(1, 56) = 64.36, p < .001$, partial eta-squared = .64) and no other main effects or interactions (Table 4). Again, there was an interaction between event and sex ($F(1, 56) = 9.17, p < .01$, partial eta-squared = .09), with men finding the Super Bowl more surprising than the women, but no interaction among event, sex, and age.

For ratings of rehearsal, an ANOVA revealed an effect of event (shuttle > Super Bowl, $F(1, 56) = 18.39, p < .001$, partial eta-squared = .16) but no interactions with age (Table 4). There also was an interaction between event and sex ($F(1, 56) = 10.16, p < .01$, partial eta-squared = .09), with women thinking about the shuttle more than the men, but men thinking about the Super Bowl more than the women. This interaction was not influenced by the age of the participants.

Memory Correlations with Importance, Surprise, and Rehearsal

We then correlated the ratings of importance, surprise, and rehearsal with the composite scores for event-related and personal details. For

the shuttle event, ratings of surprise and importance did not correlate with event-related or personal details remembered about the event. The amount of time spent thinking about or watching media coverage of the event did correlate marginally with the composite scores for event details and personal details remembered about the shuttle; these marginal correlations were present in both young and older adults (all $r > .25$, $p < .10$).

For the Super Bowl, both young and older adults showed significant correlations between how important and surprising they found the Super Bowl to be and how many event-related details and personal details they remembered at Time 2 (all $r > .6$, $p < .01$ for young and older adults). The rehearsal ratings correlated marginally with the event-related details remembered ($r > .4$, $p < .10$) for both the young and older adults, but the amount of rehearsal did not correlate significantly with increased memory for personal details of the Super Bowl.

DISCUSSION

The primary goal of this study was to assess the effects of healthy aging on memory for an event that was rated as surprising and emotional (the Columbia shuttle explosion) and for an event of temporal proximity that did not contain the same emotional salience (Super Bowl XXXVII). As anticipated, older adults had poorer memory than the young adults for event-related details and for personal details surrounding the events: They recalled less information, and the information that they recalled at Time 2 was less consistent with that supplied at Time 1 than was the case for the young adults. This general effect of age, however, did not diminish the effect of emotional salience on memory: Young and older adults were more likely to remember details from the Columbia shuttle explosion than from the Super Bowl.

This finding is consistent with a prior study that examined memory for a highly emotional and a less emotional event in young and older adults (Davidson & Glisky, 2002), and suggests that, at least in some cases, aging preserves the memory boost provided by an event's emotional content. In fact, we found that in some instances, emotional import may disproportionately benefit the memories of older as compared to young adults. For a number of recall questions, interactions between age and event resulted because older adults showed less impairment (relative to young adults) in their memory for the shuttle as compared to their memory for the Super Bowl. Thus, there may be

circumstances in which emotional content mitigates some of the age-related decrements in memory.³

As noted earlier, results have been mixed with regard to the effects of aging on emotional memory enhancement. Although it remains unclear what methodological features determine when older adults do, and do not, show normal memory enhancement, a number of possible explanations come to mind. For one, it may be that in order for older adults to show the enhancement effect, arousal levels must be sufficiently high. Using lists of words, we have shown that young adults show memory enhancement to items high in arousal (“taboo” words) and to emotional words low in arousal (e.g., death, sorrow, etc.), whereas older adults show enhancement only for arousing words (Krendl et al., 2003). Thus, information may have to exceed a critical level of arousal before enhancement is noted in older adults. Although the present study cannot speak to the neural correlates underlying the effect, many prior studies have implicated the amygdala in the enhancement effect (reviewed by Hamann, 2001; Phelps, 2004), particularly for arousing items (reviewed by Kensinger, 2004). Given that the amygdala is relatively preserved with aging (reviewed by Mather, 2003), it is tempting to speculate that when the amygdala becomes activated by an experience, older adults, like young adults, may show a boost in memory. Indeed, Davidson and Glisky (2002) found that memory for an emotional event did not correlate with performance on tasks measuring prefrontal and medial temporal-lobe function, despite these tasks’ robust correlations with other forms of memory. They argued that the lack of a correlation may have been due to amygdalar modulation of memory for the emotional event. Clearly, the link between arousal level and emotional memory enhancement in aging requires further testing, but the effect of arousal may account for some of the results within the emotional memory and aging literature.

Memory for Event-related versus Personal Details

For both age groups, the effects of emotion were more pronounced for personal details than for event-related details. This pattern of

³These results must be interpreted with caution because the ratings of the importance of the events also differed for young and older adults: Although both age groups found the shuttle event similarly important (and more important than the Super Bowl), the young adults found the Super Bowl more important than did the older adults. Thus, it is plausible that part of the reason why older adults were at a particular disadvantage in remembering information about the Super Bowl was because this event did not elicit the same sense of personal importance for them as it did for the young adults. Ratings of surprise and rehearsal, however, did not differ between the two age groups.

results is generally consistent with the hypothesis of Pezdek (Pezdek, 2003), that those aspects of the event most closely tied to the emotional response are those most likely to be remembered. Interestingly, this interaction between event and detail was more pronounced for the young adults than it was for the older adults. Future research will be needed to investigate the generality of this finding; it is currently unclear from the present study whether this interaction was due to differences in the importance of the Super Bowl for young and older adults (e.g., young adults may have been more focused on the game's proceedings than older adults) or whether there are differences in older adults' emotional responses that cause them to be more likely than young adults to rehearse the event-related, as well as the personal details, of emotional events.

Effect of Delay on Memory

Few studies have assessed the changes in memory over relatively long delays in young and older adults. Thus, another interesting finding to emerge from this study was that aging did not profoundly alter the effect of delay on the amount of information recalled. Results for the composite scores (for event-related or personal details) showed no interactions between age and delay; only one event-related detail (number of people onboard the shuttle) and one personal detail (what people were wearing) revealed a greater effect of delay on the older than the young group. The interval after which memory is assessed, therefore, does not appear to have a differential effect on the amount of information that young and older adults can recall.

Delay may, however, disproportionately affect the consistency of older adult's memories. We found that older adults were less likely than young adults to recall exactly the same information at Time 1 and Time 2. Future studies that can more carefully ascertain the accuracy of the initial reports will be needed to confirm whether this age effect reflects an increased probability of memory distortion over time in older adults (e.g., Butler, McDaniel, Dornburg, Price, & Roediger, 2004; Kensinger & Schacter, 1999; LaVoie & Faulkner, 2000).

CONCLUSIONS

To our knowledge, only one other study compared memory for a highly emotional and a less emotional real-life event in both young and older adults (Davidson & Glisky, 2002). The results of the present study corroborate that study in showing that older adults,

like young adults, are more likely to remember information about a highly emotional event than about a less emotional one. This enhancement occurred for information central to the event (event-related details) and for information regarding the reception event (personal details). The findings described here further suggest that older adults' memories may be relatively preserved for highly emotional experiences as compared to less emotional ones. When comparing their performance to that of young adults, older adults were less impaired in memory for event details and personal details for the shuttle (an event they rated as being highly important and surprising) than they were for the Super Bowl (an event they rated as less important and surprising).

REFERENCES

- Brown, R. & Kulik, J. (1977). Flashbulb memories. *Cognition*, 5, 73–99.
- Buchanan, T. & Adolphs, R. (2002). The role of the human amygdala in emotional modulation of long-term declarative memory. In S. Moore & M. Oaksford (Eds.), *Emotional cognition: from brain to behavior* (pp. 9–34). London, UK: John Benjamins.
- Butler, K. M., McDaniel, M. A., Dornburg, C. C., Price, A. L., & Roediger, H. L. (2004). Age differences in veridical and false recall are not inevitable: the role of frontal lobe function. *Psychonomic Bulletin and Review*, 11, 921–925.
- Charles, S. T., Mather, M., & Carstensen, L. L. (2003). Aging and emotional memory: the forgettable nature of negative images for older adults. *Journal of Experimental Psychology: General*, 132, 310–324.
- Christianson, S. A. (1989). Flashbulb experiences. Special, but not so special. *Memory & Cognition*, 17, 433–443.
- Cohen, G., Conway, M. A., & Maylor, E. A. (1994). Flashbulb memories in older adults. *Psychology and Aging*, 9, 454–463.
- Davidson, P. S. & Glisky, E. L. (2002). Is flashbulb memory a special instance of source memory? Evidence from older adults. *Memory*, 10, 99–111.
- Denburg, N. L., Buchanan, T. W., Tranel, D., & Adolphs, R. (2003). Evidence for preserved emotional memory in normal older persons. *Emotion*, 3, 239–253.
- Hamann, S. (2001). Cognitive and neural mechanisms of emotional memory. *Trends in Cognitive Science*, 5, 394–400.
- Kensinger, E. A. (2004). Remembering emotional experiences: The contribution of valence and arousal. *Reviews in the Neurosciences*, 15, 241–251.
- Kensinger, E. A., Anderson, A., Growdon, J. H., & Corkin, S. (2004). Effects of Alzheimer disease on memory for verbal emotional information. *Neuropsychologia*, 42, 791–800.
- Kensinger, E. A., Brierley, B., Medford, N., Growdon, J. H., & Corkin, S. (2002). Effects of normal aging and Alzheimer's disease on emotional memory. *Emotion*, 2, 118–134.

- Kensinger, E. A. & Corkin, S. (2004). The effects of emotional content and aging on false memories. *Cognitive, Affective, and Behavioral Neuroscience*, 4, 1–9.
- Kensinger, E. A., Piquet, O., Krendl, A. C., & Corkin, S. (2005). Memory for contextual details: Effects of emotion and aging. *Psychology and Aging*, 20, 241–250.
- Kensinger, E. A. & Schacter, D. L. (1999). When true memories suppress false memories: Effects of aging. *Cognitive Neuropsychology*, 16, 399–415.
- Krendl, A. C., Kensinger, E. A., & Corkin, S. (2003). Emotional memory in aging: Dissociable effects of valence and arousal. Program No. 84.11, 2003 *Abstract Viewer/Itinerary Planner*, Washington, DC: Society for Neuroscience.
- LaVoie, D. J. & Faulkner, K. (2000). Age differences in false recognition using a force-choice paradigm. *Experimental Aging Research*, 26, 367–381.
- Mather, M. (2003). Aging and emotional memory. In D. Reisberg & P. Hertel (Eds.), *Memory and emotion* (pp. 272–307). New York: Oxford University Press.
- Otani, H., Kusumi, T., Kato, K., Matsuda, K., Kern, R. P., Widner, R., Jr., & Ohta, N. (2005). Remembering a nuclear accident in Japan: Did it trigger flashbulb memories? *Memory*, 13, 6–20.
- Pezdek, K. (2003). Event memory and autobiographical memory for the events of September 11, 2001. *Applied Cognitive Psychology*, 17, 1033–1045.
- Phelps, E. A. (2004). Human emotion and memory: Interactions of the amygdala and hippocampal complex. *Current Opinion in Neurobiology*, 14, 198–202.
- Smith, M. C., Bibi, U., & Sheard, D. E. (2003). Evidence for the differential impact of time and emotion on personal and event memories for September 11, 2001. *Applied Cognitive Psychology*, 17, 1047–1055.
- Tekcan, A. I., Ece, B., Gulgoz, S., & Er, N. (2003). Autobiographical and event memory for 9/11: Change across one year. *Applied Cognitive Psychology*, 17, 1057–1066.
- Tekcan, A. I. & Peynircioglu, Z. F. (2002). Effects of age on flashbulb memories. *Psychology and Aging*, 17, 416–422.
- Winograd, E. & Killinger, W. A., Jr. (1983). Relating age at encoding in early childhood to adult recall: Development of flashbulb memories. *Journal of Experimental Psychology: General*, 112, 413–422.
- Wright, D. B., Gaskell, G. D., & O’Muircheartaigh, C. A. (1998). Flashbulb memory assumptions: Using national surveys to explore cognitive phenomena. *British Journal of Psychology*, 89, 103–121.
- Yarmey, A. D. & Bull, M. P. (1978). Where were you when President Kennedy was assassinated? *Bulletin of the Psychonomic Society*, 11, 133–135.

Appendix 1. Survey questions

Questions about shuttle event

Questions about Super Bowl

Event-Related Questions

Name: What was the name of the shuttle that was lost?
Time: What day of the week was the shuttle lost? At what time was the shuttle lost?
Place: Where was the shuttle lost?
People: How many people were aboard the shuttle? Do you remember anyone in particular who was aboard the shuttle?
Other: What additional information do you remember about the event surrounding the shuttle being lost? Are there any images that you remember seeing about the event?

Event-Related Questions

Name: What was the name of the team that won the game?
Time: What was the date of the game? What time did the game start?
Place: Where was the game played?
People: What were the teams that played in the game? Who performed at the half-time show?
Other: What additional information do you remember about the Super Bowl game? Are there any specific images that you remember from the game, or the halftime show, or any of the commercials?

Personal Detail Questions

Reception: How did you first learn of the news? Who were you with when you when you learned the news?
Location: Where were you when you first learned the news?
Activities: What were you doing at the time that you learned the news?
Clothing: What were you wearing at the time that you learned the news?
Food: What had you eaten for breakfast the morning you learned the news? For lunch that day?
Weather: What was the weather like outside when you learned the news?
Other: Is there any other information you remember about the 1-2 hours surrounding the time when you learned of the event?

Personal Detail Questions

People: Who were you with as you watched the game?
Location: Where did you watch the game?
Activities: What were you doing as you watched the game?
Clothing: What were you wearing as you watched the game?
Food: What had you eaten for breakfast that morning? For lunch that day? As you watched the game?
Weather: What was the weather like outside on that day?
Other: Is there any other information you remember about the events surrounding your watching of the game?

Assessment of Surprise, Importance, and Rehearsal

Importance: How emotionally important was the event for you?
Surprise: How surprising was the event?
Rehearsal: How much time did you spend watching the news or talking about the event? How frequently have you thought of the event since you first learned of it?

Assessment of Surprise, Importance, and Rehearsal

Importance: How emotionally important was the event for you?
Surprise: How surprising was the event?
Rehearsal: How much time did you spend watching the game or talking about it with others? How frequently have you thought of the game since you first watched it?

Note. The survey questions regarding the shuttle event and Super Bowl were designed to be as parallel as possible, given the inherent differences in the events.