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Memory and Emotions for the September 11, 2001, Terrorist Attacks in Patients With Alzheimer's Disease, Patients With Mild Cognitive Impairment, and Healthy Older Adults

Andrew E. Budson
Brigham and Women's Hospital and Harvard Medical School

Jon S. Simons
Harvard University

Alison L. Sullivan
Brigham and Women's Hospital

Jonathan S. Beier
Harvard University

Paul R. Solomon
Williams College and Southwestern Vermont Medical Center

Leonard F. Scinto and Kirk R. Daffner
Brigham and Women's Hospital and Harvard Medical School

Daniel L. Schacter
Harvard University

National traumatic events can produce extremely vivid memories. Using a questionnaire administered during telephone interviews, the authors investigated emotional responses to, and memory for, the September 11, 2001, terrorist attacks in patients with Alzheimer's disease (AD), patients with mild cognitive impairment (MCI), and healthy older adults in the initial weeks following the event and again 3–4 months later. There were several notable findings. First, patients with AD showed less memory than patients with MCI and older adults. Second, patients with AD, but not patients with MCI or older adults, appeared to retain more memory for personal versus factual information. Third, patients with AD and older adults did not differ in the intensity of their reported emotional responses to the attacks, whereas patients with MCI reported relatively less intense emotional responses. Last, distortions of memory for personal information were frequent for all participants but were more common in patients with AD.

After the attacks of September 11, 2001, President George W. Bush, in his address to the nation, stated, "None of us will ever forget this day" (Bush, 2001). For most Americans this assessment is undoubtedly correct. Television and other media coverage was graphic and widespread (Barringer & Fabrikant, 2001; Kakutani, 2001; Shales, 2001). Emotional arousal surrounding this event was extremely high: Even if they had no personal connection to the events, large numbers of Americans experienced stress symptoms related to the attacks (Schuster et al., 2001), and it has been predicted that posttraumatic stress disorder (PTSD) will develop in many of these people (Yehuda, 2002). In addition to producing stress, emotional arousal may also lead to improved memory for events (Cahill & McGaugh, 1995; Christianson & Loftus, 1987; Heuer & Reisberg, 1990).

Work by Cahill, McGaugh, and others has suggested that memory for emotional events differs from memory for nonemotional events because of the selective involvement of the amygdala in the former (see Cahill & McGaugh, 1998, for review). Studies using functional neuroimaging and patients with brain lesions have provided evidence that, whereas the hippocampal region may play a general role in episodic remembering, recruitment of the amygdala is specifically associated with emotional memories (Alkire, Haier, Fallon, & Cahill, 1998; Canli, Zhao, Brewer, Gabrieli, & Cahill, 2000; Hamann, Cahill, McGaugh, & Squire, 1997; Packard & Cahill, 2001). For example, Hamann et al. (1997) found that the enhancement of memory for emotionally arousing story elements was equally strong in amnesic patients and controls. This finding suggests that the degree of emotional enhancement of memory may be independent of hippocampal function. Using functional magnetic resonance imaging (fMRI), Williams et al. (2001) found that when participants viewed fearful faces, two different brain networks were active. One network included the amygdala and

Andrew E. Budson, Leonard F. Scinto, and Kirk R. Daffner, Division of Cognitive and Behavioral Neurology, Department of Neurology, Brigham and Women's Hospital, Boston, Massachusetts, and Harvard Medical School; Jon S. Simons, Jonathan S. Beier, and Daniel L. Schacter, Department of Psychology, Harvard University; Alison L. Sullivan, Division of Cognitive and Behavioral Neurology, Department of Neurology, Brigham and Women's Hospital; Paul R. Solomon, Department of Psychology, Williams College, and Southwestern Vermont Medical Center, Bennington, Vermont.

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Correspondence concerning this article should be addressed to Andrew E. Budson, Division of Cognitive and Behavioral Neurology, Department of Neurology, Brigham and Women's Hospital, 75 Francis Street, Boston, MA 02115. E-mail: abudson@partners.org

medial frontal cortex and was associated with autonomic arousal as measured by skin conductance responses. The other network included the hippocampus and lateral frontal cortex and was not associated with autonomic arousal.

Patients with Alzheimer's disease (AD) show pathology in amygdala and other structures of the limbic system related to emotional processing (Callen, Black, Gao, Caldwell, & Szalai, 2001; Chu, Tranel, Damasio, & Van Hoesen, 1997; Hopper & Vogel, 1976), in addition to hippocampal pathology. Therefore, researchers have hypothesized that patients with AD would show impairment in processing of, and memory for, emotional stimuli. Most studies have, in fact, found that patients with AD show impairments in processing emotional stimuli (Albert, Cohen, & Koff, 1991; Allender & Kaszniak, 1989; Brosgole, Kurucz, Plahovinsak, & Gumiela, 1981; Cadieux & Greve, 1997). However, many of these studies suggested that the patients' emotional impairment was secondary to perceptual or cognitive difficulties and not to a primary impairment in emotional processing (Albert et al., 1991; Brosgole et al., 1981; Cadieux & Greve, 1997).

Three laboratory studies have investigated emotional memory in patients with AD. Kazui et al. (2000) found that patients with AD and older adults both remembered an emotionally arousing story better than a neutral one; the extent of memory improvement was similar in patients and controls. Moayeri, Cahill, Jin, and Plotkin (2000) found that patients with AD remembered more emotionally negative parts of an audiovisual story compared with the emotionally neutral parts. However, because the control participants showed a ceiling effect, Moayeri et al. could not evaluate whether the magnitude of the emotional memory effect in the patients was comparable with that in healthy older adults. Hamann, Monarch, and Goldstein (2000) studied emotional responses and emotional memory in patients with AD compared with older adults. Patients with AD demonstrated normal emotional responses to picture stimuli as measured by arousal ratings and skin conductance responses. Whereas older adults showed an emotional memory effect for positive and negative pictures on a free-recall test, patients with AD showed an emotional memory effect only for positive pictures. On a recognition test, patients with AD did not show the emotional memory effect for negative pictures observed in older adults; neither group showed an effect for positive pictures. Thus, Hamann et al. demonstrated a dissociation between the intact emotional responses and impaired emotional memory effect for negative stimuli in patients with AD.

One study examined the extent to which patients with AD could remember a natural disaster they survived (the Kobe earthquake) compared with their memory for a MRI scan they underwent (Ikeda et al., 1998). Using a 12-item questionnaire, Ikeda et al. found that 86% of the patients remembered the earthquake, whereas only 31% remembered the MRI scan. In a follow-up study, Mori et al. (1999) correlated the volume of the amygdala and hippocampus with the amount of information that patients could recall about the earthquake. Although both structures showed an initial positive correlation, only the amygdala correlation remained significant after effects of age, sex, education, whole brain volume, and disease severity were accounted for.

In the present study, we examined memory for, and emotional responses to, the September 11, 2001, terrorist attacks in patients with AD, patients with mild cognitive impairment (MCI),[1] and healthy older adults in the weeks following the attacks (9/19/2001–10/02/2001) and again approximately 3 to 4 months later (12/11/2001–1/17/2002). We used this study to answer a number of questions. First, would patients and older adults report similar emotions and emotional intensity to a real-world event outside the laboratory? Second, how would the two patient groups compare with the older adults in their memory for how they personally heard the news of the attacks (*personal information* is similar to the "personal reception context" of Larsen, N. R. Brown, and their colleagues; N. R. Brown, Rips, & Shevell, 1985; Larsen, 1988; Larsen & Thompson, 1995)? Third, how would these groups compare in their memory for the factual details of the events of September 11th (*factual information* is similar to the "news" or "core event" of Larsen, N. R. Brown, and their colleagues; N. R. Brown et al.; Larsen; Larsen & Thompson)? Last, would the patients show more distortions of their memory over time than the older adults? We believe that the answers to these questions will provide insights not readily available through laboratory studies into emotion and memory in healthy and memory-impaired older adults.

Method

Participants

Twenty-two patients with a clinical diagnosis of AD (National Institute of Neurological and Communicative Disorders and Stroke–Alzheimer's Disease and Related Disorders Association criteria used; McKhann, Drachman, Folstein, Katzman, & Price, 1984), 21 patients with a diagnosis of MCI (Petersen et al., 2001), and 23 healthy older adults were recruited for the study. Patients with AD and MCI were recruited from the clinical population at the Memory Disorders Unit, Brigham and Women's Hospital (Boston, MA). Older adults were recruited from participants in a longitudinal study of normal aging at Brigham and Women's Hospital, from spouses and friends of the patients, and from flyers and posters placed in senior centers in and around Boston. Oral informed consent was obtained from all participants and their caregivers (where appropriate). The study was approved by the human subjects committee of Brigham and Women's Hospital. Participants did not receive compensation for their participation. Participants were excluded if they were characterized by clinically significant depression, alcohol or drug use, cerebrovascular disease, traumatic brain damage, or if English was not their primary language, as verified by their clinical and research records. The participant groups were matched on the basis of gender (AD: 12 men, 10 women; MCI: 11 men, 10 women; older adults: 9 men, 14 women), age (M_{AD} = 77.9 years, range = 68–90 years; M_{MCI} = 74.7 years, range = 54–88 years; $M_{older\ adult}$ = 76.0 years, range = 64–89 years), and education (M_{AD} = 14.2 years, range = 11–20 years; M_{MCI} = 15.1 years, range = 8–23 years; $M_{older\ adult}$ = 13.9 years, range 8–20 years). Patients with AD were in the mild-to-moderate stages of disease; Mini-Mental Status Examinations (MMSE; Folstein, Folstein, & McHugh, 1975) obtained within a year of their interview had a mean score of 22.6 and ranged from 16 to 27. One patient with AD, 1 with MCI, and 1 older adult did not participate in the 3-month interview and were excluded from the 3-month analysis. Recall data from 7 patients with AD, 3 patients with MCI, and 8 older adults were not recorded at the first time point because of experimenter error and were thus excluded from the recall analyses.

[1] Patients with MCI are those individuals who show isolated memory impairment, are otherwise functioning well, and do not meet criteria for AD or other dementia. These patients are thought to represent the clinical transition stage between normal aging and early AD (Petersen et al., 2001).

Questionnaire

Design. The questionnaires were loosely based on a previously used questionnaire (Schmolck, Buffalo, & Squire, 2000) and were developed jointly by the 9/11 Memory Consortium (members are Randy L. Buckner, Andrew E. Budson, John Gabrieli, William Hirst, Marcia K. Johnson, Cindy Lustig, Keith Lyle, Mara Mather, Kevin Ochsner, Elizabeth A. Phelps, Daniel L. Schacter, Jon S. Simons, & Chandan Vaidya). The questionnaires were developed to better understand memory, emotions, and their changes over time for a highly emotional public event. Because the questionnaires were primarily developed for young adults responding on paper, these questionnaires were modified slightly for use in the present study; see Appendix A, which is on the Web at http://dx.doi.org/10.1037/0894-4105.18.2.315.supp, for details. The first questionnaire used in the present study is available on the Web at http://dx.doi.org/10.1037/0894-4105.18.2.315.supp as Appendix B; the second was virtually identical with the exception of some minor changes in wording.

In brief, the questionnaires consisted of 8 open-ended questions (Questions 1, 28, 39–44), 13 personal information questions (Questions 2–12, 27, part of 29), 6 factual information questions (22-26, part of 29), 7 questions regarding participants' current emotional state (Questions 3–19), 7 questions regarding participants' predicted future emotional state (Questions 30–36), several miscellaneous questions related to how well participants predicted they would remember their personal information (Questions 12.1, 12.2), the extent to which participants engaged in activities related to the events of September 11th (Questions 20, 21, 37), and how likely they thought another terrorist attack was (Question 38). However, only the personal and factual information questions (Questions 2–12, 22–27, 29), the current and predicted future emotional state questions (Questions 13–19, 30–36), the questions related to the extent to which participants reviewed the events of September 11th (Questions 20, 21, 37), and how well participants predicted they would remember their personal information (Questions 12.1, 12.2) are presented in this study. There were also a number of demographic questions. The majority of the personal and factual information questions included a recognition component as well as a recall component such that if a participant was unable to recall the information or gave an incorrect answer that was not one of the recognition choices, they were provided with the opportunity to choose their answer from a list of alternatives. It should be noted that our distinction between personal and factual information was similar to the contrasts made between "personal reception context" and "news" or "core events" by N. R. Brown et al. (1985), Larsen (1988), and Larsen and Thompson (1995).

Scoring. Detailed procedures for scoring the questions were developed by the 9/11 Memory Consortium and then modified for use in the present study. These modified scoring procedures are included as Appendix C on the Web at http://dx.doi.org/10.1037/0894-4105.18.2.315.supp. The full coding manual prepared by the 9/11 Memory Consortium is available from the authors on request. In brief, the majority of the personal and factual information questions were scored first for recall and then for recognition.

Personal information questions were not scored for accuracy initially but simply for the presence of a recall or recognition response (scored as 1) versus no response (scored as 0), with "I don't know" or the equivalent coded as a nonresponse. Verification of the accuracy of the patients' personal information responses was performed post hoc as described in the *Verified responses* section. Factual information questions were scored both for the presence of recall and recognition responses and for the accuracy of those responses (*accurate* = 1, *inaccurate and nonresponses* = 0). Some of these questions (8, 23–25, 29) necessitated multiple answers and thus were scored as multiple questions with their own answers. For example, because Question 23 asked participants which airline each of the four planes was from, this question had four answers and was scored as four separate questions labeled 23a, 23b, 23c, and 23d. Emotional intensity questions (13–18, 30–35) were scored on a 5-point scale (1 = *low*, 5 = *high*). Questions 19 and 36 (other emotions experienced) were scored for the presence or absence of other emotions experienced. Questions 20 and 21 (reviewing the events of September 11th) were scored on a 5-point scale (1 = *low*, 5 = *high*). Question 37 was difficult for all participants to answer and participants frequently responded in ways that made scoring difficult; for this reason the answers were excluded from the analyses (see the Results section for scoring and analyses of the follow-up interview). A brief summary of the scoring of distortions is available in Appendix A on the Web at http://dx.doi.org/10.1037/0894-4105.18.2.315.supp.

Verified responses. We performed post hoc analyses in an effort to confirm the patients' personal responses. Of the 15 questions that constituted the personal information section (2–12, 27, part of 29, see Appendix B on the Web at http://dx.doi.org/10.1037/0894-4105.18.2.315.supp), 6 of these questions (Questions 2: "time heard", 3: "source of information", 4: "where you were?", 6: "who else was there?", 11: "personal losses suffered", and 12: "inconvenience incurred") would be reasonably likely to be the same for both the patient and his or her healthy spouse. Twelve of the 22 patients with AD and 3 of the 21 patients with MCI had a spouse who also participated in the study and thus was available to verify the patients' responses. The responses of the 12 patients with AD for these 6 questions were verified by their spouses 82% and 83% of the time for recall and recognition, respectively. We then performed an analysis to determine if there were any differences in age, education, and MMSE scores between the 12 patients with AD with verified responses versus the 10 patients with unverified responses; no differences were present, $F\text{s}(1, 20) < 1$. Therefore, we applied the verifications factors .82 and .83 to the mean personal recall and recognition responses, respectively, for each patient with AD. The response of the 3 patients with MCI for these 6 questions was verified by their spouses 100% of the time for both recall and recognition responses. Given that there were few patients with MCI with verified responses and that their responses were verified 100% of the time in this small sample, no correction was applied to the personal responses of the patients with MCI.

These same verification factors were applied to the personal information of the patients with AD at the follow-up interview, which reduced their correct responses and increased their distorted responses. To provide an analogous correction for the factual information analyses, only consistent and accurate responses were considered correct (rather than just consistent with the initial interview response), and the consistent but inaccurate responses were considered distortions.

Procedure

Each participant was individually recruited by telephone from 9/19/2001 to 10/02/2001 and then again from 12/11/2001 to 1/17/2002. A script approved by the Institutional Review Board was read to participants (and their caregivers in the case of the patients with AD). After obtaining informed consent, demographic information was obtained. At this point, only the participant (and not the caregiver, if applicable) remained on the phone with the experimenter. If applicable, participants were also urged to not listen to the responses of another household member by going to a different room and to always provide only their own responses. The experimenter then went through the questionnaire, item by item, and recorded the responses on a paper copy of the questionnaire. For the personal and factual information questions, 2–12 and 22–27, the participants were first asked to recall the requested information and were then given a list of answers from which to choose from.

Results

Initial Interview

Averages of the responses to personal and factual information questions from the initial interview are shown in Table 1 as a function of group (patients with AD, patients with MCI, and older adults) and response mode (recall vs. recognition). In these anal-

Table 1
Results of the Initial Interview

Variable	AD *M*	AD Verified *M*	MCI *M*	Older adults *M*
Personal recall				
Response	.87	.72	.97	1.00
Personal recognition				
Response	.91	.74	.98	1.00
Factual recall				
Response	.23		.67	.78
Accuracy	.10		.55	.68
Factual recognition				
Response	.40		.69	.81
Accuracy	.17		.56	.72

Note. AD = Alzheimer's disease; MCI = Mild cognitive impairment.

yses a "1" indicates the presence of a response and "0" indicates its absence. The averages of the verified personal responses for the patients with AD are also shown. Analyses of personal information were performed both with verified and unverified responses; because few differences were observed in these two analyses, only the verified responses are presented here. Table 1 also displays data concerning the accuracy of participants' factual information. (An expanded version of Table 1 that includes responses to individual personal and factual questions is available in Appendix D, which is on the Web at http://dx.doi.org/10.1037/0894-4105.18.2.315.supp.) Figure 1 shows the emotional intensity reported by participants at the initial interview to the different emotions as a function of group (patients with AD, patients with MCI, and older adults) and time (current vs. future emotions). To enhance readability of the tables, within-group variation is reported as the mean square error in the text of the results below, rather than as standard deviation or standard error in the tables. All statistical analyses were performed using SPSS 10.05 software (SPSS Inc., Chicago, IL).

Responses to personal and factual information questions. We compared verified recall responses to personal information with accurate recall responses to factual information in patients with AD and MCI and in healthy older adults. These analyses revealed that all participants recalled more verified personal than accurate factual information; patients with AD recalled less information than patients with MCI, who in turn showed a trend toward recalling less information than older adults; and the difference between verified personal and accurate factual information was greater in patients with AD than with the other two groups (see Table 1).

An analysis of variance (ANOVA) with group (AD, MCI, older adults) as a between-subjects variable and information type (personal vs. factual) as a within-subject variable demonstrated effects of group, $F(2, 45) = 61.21$, $MSE = 0.026$, $p < .0005$; information type, $F(1, 45) = 242.80$, $MSE = 0.020$, $p < .0005$; and an interaction between them, $F(2, 45) = 8.37$, $MSE = 0.020$, $p = .001$. To understand the effect of group, the ANOVA was repeated with pairs of the groups that demonstrated that patients with AD recalled less information than those with MCI, $F(1, 31) = 66.10$, $MSE = 0.031$, $p < .0005$, and older adults, $F(1, 28) = 134.00$, $MSE = 0.021$, $p < .0005$; patients with MCI showed a marginally significant trend toward recalling less information than older adults, $F(1, 31) = 3.85$, $MSE = 0.026$, $p = .059$. These ANOVAs with pairs of the groups also demonstrated that the interaction in the overall ANOVA was due to the greater difference between the recall of personal versus factual information in the patients with AD than in the other two groups, as demonstrated by a Group × Information Type interaction between the patients with AD and those with MCI, $F(1, 31) = 6.67$, $MSE = 0.022$, $p = .015$, and with older adults, $F(1, 28) = 25.14$, $MSE = 0.013$, $p < .0005$, but not between patients with MCI and older adults, $F(1,31) = 1.88$, $MSE = 0.025$, $p = .181$.

As with the recall responses, we also compared verified recognition responses to personal information with accurate recognition responses to factual information in patients with AD, MCI, and healthy older adults. These analyses revealed that all participants recognized more verified personal than accurate factual information; patients with AD recognized less information than patients with MCI, who in turn recognized less information than older adults; and the difference between verified personal and accurate factual information was greatest in patients with AD and least in the older adults, and the patients with MCI were in between (see Table 1).

An ANOVA, with group (AD, MCI, older adults) as a between-subjects variable and information type (personal vs. factual) as a within-subject variable demonstrated effects of group, $F(2, 63) = 83.64$, $MSE = 0.024$, $p < .0005$; information type, $F(1, 63) = 366.85$, $MSE = 0.016$, $p < .0005$; and an interaction between them, $F(2, 63) = 14.53$, $MSE = 0.016$, $p < .0005$. To understand the effect of group, the ANOVA was repeated with pairs of the groups that demonstrated that patients with AD recognized less information than those with MCI, $F(1, 41) = 71.55$, $MSE = 0.030$, $p < .0005$, and older adults, $F(1, 43) = 185.37$, $MSE = 0.020$, $p < .0005$; and patients with MCI recognized less information than older adults, $F(1, 42) = 7.34$, $MSE = 0.022$, $p = .010$. The interactions in the ANOVAs with pairs of the groups shows that the interaction in the overall ANOVA was present because patients with AD showed a greater difference between the recognition of personal versus factual information than those with MCI, $F(1, 41) = 6.68$, $MSE = 0.018$, $p = .013$, and older adults, $F(1, 43) = 43.56$, $MSE = 0.011$, $p < .0005$, and because patients with MCI showed a greater difference between personal and factual information than older adults, $F(1, 42) = 5.36$, $MSE = 0.020$, $p = .026$.

Responses to emotional questions. Ten patients with AD, 11 patients with MCI, and 6 older adults gave no response to 1 or more of the 12 emotional intensity questions, constituting a small amount of the total data (64 of 792 responses, or 8%). Analyses performed to determine whether any patterns were present in these missing responses is available in Appendix A on the Web at http://dx.doi.org/10.1037/0894-4105.18.2.315.supp.

Overall, participants reported differing levels of intensity to the different emotions and predicted that they would feel less sadness, frustration, and shock in the future (Figure 1). A repeated measures ANOVA with time (present vs. future) and emotion (sadness, anger, fear, frustration, confusion, shock) as within-subject variables and group (patients with AD, patients with MCI, and older adults) as a between-subjects variable demonstrated main effects of time, $F(1, 63) = 17.21$, $MSE = 0.941$, $p < .0005$; emotion, $F(5, 315) = 47.14$, $MSE = 1.59$, $p < .0005$; and group, $F(2,$

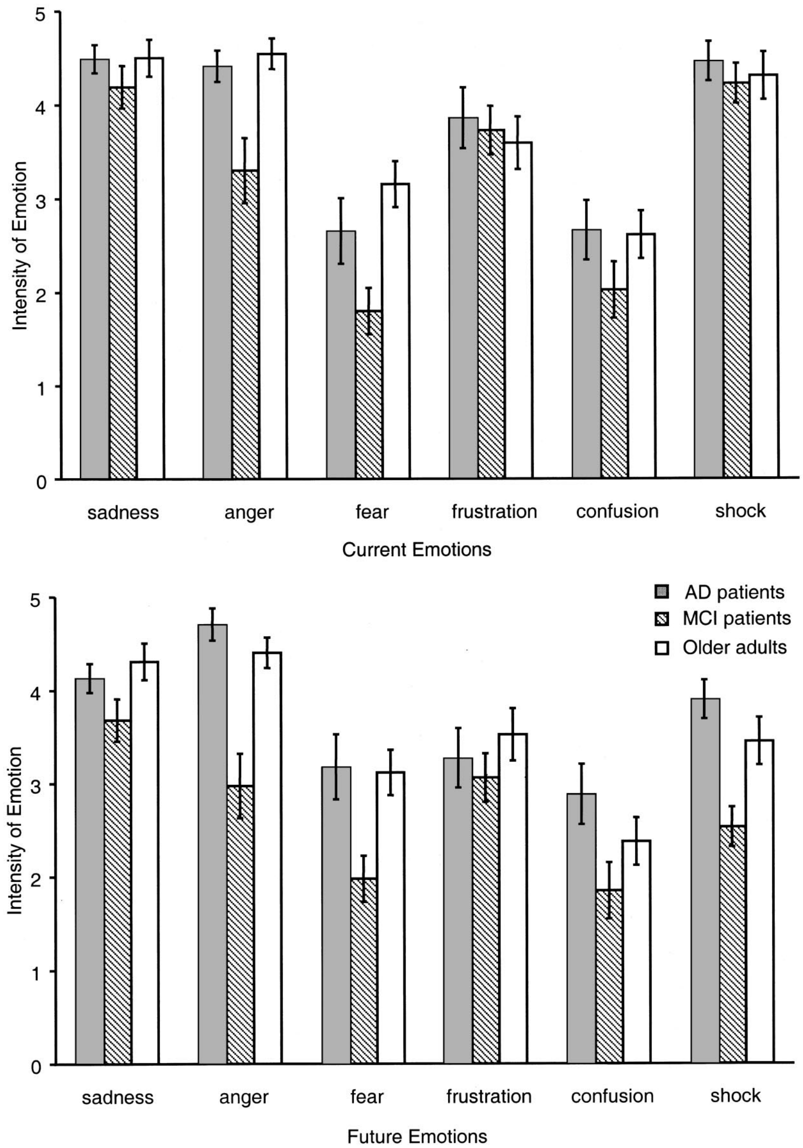

Figure 1. Intensity of emotional reaction on a 1 (*low*)- to 5 (*high*)-point scale for patients with Alzheimer's disease (AD) and mild cognitive impairment (MCI) and older adults as a function of emotion (sadness, anger, fear, frustration, confusion, shock) and time (current [top] vs. future [bottom]). Error bars show the standard error of the mean.

63) = 7.03, *MSE* = 6.66, p = 0.002; as well as significant interactions between time and group, $F(2, 63) = 3.59$, $MSE = 0.941$, $p = .033$; emotion and group, $F(10, 315) = 2.11$, $MSE = 1.59$, $p = .023$; and time and emotion, $F(5, 315) = 8.72$, $MSE = 0.721$, $p < .0005$. The three-way interaction was not significant, $F(10, 315) = 1.24$, $MSE = 0.721$, $p = .266$. The effect of time was present because participants predicted that they would feel less intensely overall in 1 year compared with how they currently felt. The effect of emotion indicates that participants reported varying levels of intensity to the different emotions (see Figure 1). The Time × Emotion interaction is likely present because some emotions were predicted by participants to change over time, sadness: $t(65) = 3.64$, $MSE = 0.095$, $p = .001$; frustration: $t(65) = 2.65$, $MSE = 0.162$, $p = .010$; shock: $t(65) = 5.49$, $MSE = 0.188$, $p < .0005$, whereas others were not, anger and confusion: $t(65) < 1$; fear: $t(65) = 1.35$, $MSE = 0.163$, $p = .182$. To understand the effect of group and the interactions with group, separate ANOVAs were performed with pairs of the groups. Note that because the three-way interaction was not significant and the effects of time, emotion, and the Time × Emotion interaction have already been discussed, they are not reported in the following post hoc analyses.

Patients with AD reported higher levels of anger, fear, confusion, and shock than those with MCI (Figure 1). Comparisons between these groups demonstrated a main effect of group, $F(1, 41) = 10.76$, $MSE = 6.97$, $p = .002$, as well as interactions between time and group, $F(1, 41) = 7.48$, $MSE = 0.892$, $p = .009$, and emotion and group, $F(5, 205) = 2.65$, $MSE = 1.64$, $p = .024$.

The effect of group indicates that patients with AD showed greater emotional intensity compared with patients with MCI. The Time × Group interaction was present because patients with AD did not think their emotions would change in one year, $F(1, 21) < 1$, whereas patients with MCI thought their emotions would diminish in intensity, $F(1, 20) = 26.80$, $MSE = 0.661$, $p < .0005$. The Emotion × Group interaction is likely attributable to the fact that patients with AD and MCI differed in their intensity to some emotions but not others. Compared with patients with MCI, patients with AD reported more anger, $F(1, 41) = 16.72$, $MSE = 2.56$, $p < .0005$; more fear, $F(1, 41) = 7.93$, $MSE = 2.80$, $p = .007$; more confusion, $F(1, 41) = 5.61$, $MSE = 2.62$, $p = .023$; and more shock, $F(1, 41) = 6.31$, $MSE = 2.15$, $p = .016$; they did not report more sadness, $F(1, 41) = 1.64$, $MSE = 1.74$, $p = .207$, or frustration, $F(1, 41) < 1$.

Interestingly, although the analysis of patients with AD and patients with MCI generated numerous main effects and interactions reflecting the different responses of the two groups, comparisons between patients with AD and older adults showed no effect of group, $F(1, 43) < 0.1$, and no interactions with group, Time × Group, $F(1, 43) < 1$; Emotion × Group, $F(5, 215) < 1$, suggesting that these two groups reported similar emotional intensity.

Because we have seen that patients with AD and older adults reported similar emotional intensity whereas patients with AD and those with MCI differed, it is not surprising that patients with MCI and older adults also differed in their emotional intensity. An ANOVA showed an effect of group, $F(1, 42) = 9.88$, $MSE = 6.77$, $p = .003$, and an Emotion × Group interaction, $F(5, 210) = 3.09$, $MSE = 1.57$, $p = .010$. The Time × Group interaction, $F(1, 42) = 2.95$, $MSE = 0.856$, $p = .093$, did not reach significance. The effect of group shows that, compared with older adults, patients with MCI reported less emotional intensity overall. The interaction of group and emotion indicates that intensity differences were present with some questions but not all. Compared with older adults, patients with MCI reported less anger, $F(1, 42) = 14.94$, $MSE = 2.62$, $p < .0005$, and less fear, $F(1, 42) = 17.07$, $MSE = 2.00$, $p < .0005$; they did not report significantly less sadness, $F(1, 42) = 2.33$, $MSE = 2.06$, $p = .134$; frustration, $F(1, 42) < 1$; confusion, $F(1, 42) = 2.31$, $MSE = 2.95$, $p = .136$; or shock, $F(1, 42) = 2.33$, $MSE = 2.37$, $p = .134$.

Reviewing of the events of September 11th and memory prediction. Separate ANOVAs demonstrated that patients with AD and MCI and older adults did not differ in how closely they followed the September 11th media coverage—Question 20, $F(2, 62) = 1.18$, $MSE = 0.956$, $p = .314$—or how much they talked about the attacks—Question 21, $F(2, 60) < 1$.

Patients with AD and MCI did not think they would remember their personal information as well as older adults thought they would, and all participants thought they would retain more of this information in 3 months (Question 12.1) compared with 1 year (Question 12.2). Nonetheless, participants in all groups on average thought they would remember these details quite well (see Table 2). An ANOVA with time (3 months vs. 1 year) as a within-subject variable and group (patients with AD, patients with MCI, and older adults) as a between-subjects variable showed significant main effects of time, $F(1, 59) = 8.15$, $MSE = 0.168$, $p = .006$, and group, $F(1, 59) = 4.44$, $MSE = 1.50$, $p = .016$; there was no interaction between these two variables, $F(2, 59) = 1.50$, $MSE = 0.168$, $p = .232$. Repeating the analysis with pairs of the groups showed no differences between patients with AD and MCI, $F(1, 38) < 1$, and significant differences between older adults and patients with AD, $F(1, 39) = 4.28$, $MSE = 1.17$, $p = .045$, and those with MCI, $F(1, 41) = 10.35$, $MSE = 1.25$, $p = .003$.

Table 2
Responses to Memory Prediction Questions in Patients With AD, Patients With MCI, and Older Adults

Question	AD	MCI	Older adults
12.1 (predicted quality of memory in 3 months)	4.21	4.07	4.85
12.2 (predicted quality of memory in 1 year)	4.13	3.76	4.55

Note. Responses were based on a 1 (*low*)- to 5 (*high*)-point scale. AD = Alzheimer's disease; MCI = mild cognitive impairment.

Follow-Up Interview

Table 3 shows the results of the follow-up interview. For these data, we were most interested to learn what had become of participants' initial interview responses. Therefore, we split the initial responses into correct responses, changed or distorted responses (see the Appendix at the end of this article for examples; a brief summary of scoring distortions is available in Appendix A on the Web at http://dx.doi.org/10.1037/0894-4105.18.2.315.supp), and response failures ("I don't know" or the equivalent); the sum of these three components thus equaled the initial interview responses. We then adjusted the data such that these three components would equal 1.00 to compensate for group differences in participants' initial memory for the event. (In this way the differences present would reflect the change in participants' responses over the 3- to 4-month retention interval, rather than simply reflecting memory differences at the initial time point, which were presented above.) The personal and factual data were treated the same, with the exception that in the factual analysis we also looked for improvements, that is, responses that were incorrect in the initial interview and correct on the follow-up interview. Improvements were, however, negligible and are therefore reported in Table 3 but not analyzed. Table 3 also shows the data after the verification factors for personal information were applied to the data. As discussed above in the Method section, these factors reduced correct responses and increased distorted responses of the personal information in the patients with AD. Because verified personal information was being used, responses for factual information were only counted as correct responses in these analyses if the factual information was accurate in addition to being the same as participants' first time-point answers. The results analyzed were very similar between verified and unverified responses and between unadjusted and adjusted responses. Because we believe that the adjusted and verified data are the most accurate reflection of how participants' responses changed from the initial to the follow-up interview, these analyses are presented.

Summary of follow-up results to personal and factual information questions. We compared participants' levels of correct responses, distorted or changed responses, and failures to respond for verified responses with personal information questions and accurate responses for factual information questions in patients with AD and MCI and in healthy older adults. Overall participants

Table 3
Results of the Follow-Up Interview

Variable	AD			MCI		Older adults	
	Unverified	Unadjusted	Adjusted	Unadjusted	Adjusted	Unadjusted	Adjusted
Personal recall							
Correct	.46	.38	.45	.68	.70	.74	.74
Distortion	.29	.37	.44	.24	.25	.25	.25
Failure	.12	.12	.12	.05	.05	.02	.02
Total	.87	.87	1.00	.97	1.00	1.00	1.00
Personal recognition							
Correct	.45	.37	.40	.67	.68	.75	.75
Distortion	.34	.43	.47	.29	.30	.25	.25
Failure	.12	.12	.13	.02	.02	.01	.01
Total	.91	.91	1.00	.98	1.00	1.00	1.00
Factual recall							
Correct		.06	.17	.45	.61	.58	.72
Distortion		.07	.23	.11	.16	.14	.16
Failure		.09	.50	.08	.17	.07	.09
Improvement		.01	.04	.04	.05	.03	.03
Total		.24	1.00	.68	1.00	.81	1.00
Factual recognition							
Correct		.10	.21	.46	.60	.64	.78
Distortion		.10	.21	.11	.18	.08	.10
Failure		.16	.46	.07	.13	.06	.07
Improvement		.04	.08	.03	.03	.02	.03
Total		.41	1.00	.70	1.00	.83	1.00

Note. Total = proportion of responses at the initial interview. The adjusted analyses were calculated for each participant and then averaged together. The adjusted means cannot be simply calculated from the unadjusted means because of order-of-operations violations. AD = Alzheimer's disease; MCI = mild cognitive impairment.

showed higher levels of correct than distorted responses and higher levels of distorted than failed responses. Patients with AD showed lower levels of correct recall responses than patients with MCI and older adults (who did not differ). Patients with AD also showed lower levels of correct recognition responses than patients with MCI, who in turn showed lower levels than older adults. Patients with AD, but not those with MCI or older adults, showed significantly higher levels of correct recall and recognition responses to personal versus factual questions. Patients with AD showed higher levels of distorted recall responses than the other two groups, who did not differ. Patients with AD showed higher levels of distorted recognition responses than patients with MCI, who in turn showed higher levels than older adults. Participants overall showed higher levels of these distorted responses to personal compared with factual questions, and for the recognition data this difference was greatest in the patients with AD. Levels of recall response failures were higher in patients with AD than patients with MCI and older adults. Levels of recognition response failures were higher in patients with AD than patients with MCI, which were in turn higher than the levels in older adults. These levels of response failures were also higher for factual versus personal questions for participants overall, and this difference was greatest in the patients with AD.

Recall responses to personal and factual information questions. An ANOVA of the recall data with group (AD, MCI, older adults) as a between-subjects variable and information type (personal vs. factual) and response type (correct, distorted, failed) as within-subject variables revealed effects of information type, $F(1, 43) = 18.39$, $MSE = 0.002$, $p < .0005$, and response type, $F(2, 86) = 84.07$, $MSE = 0.050$, $p < .0005$, as well as Group × Response Type, $F(4, 86) = 21.17$, $MSE = 0.050$, $p < .0005$; Information Type × Response Type, $F(2, 86) = 18.37$, $MSE = 0.043$, $p < .0005$; and Group × Information Type × Response Type interactions, $F(4, 86) = 3.98$, $MSE = 0.043$, $p = .005$. As expected, the effect of group and the Group × Information Type interaction were not significant, $Fs(2, 43) = 1.29$, $MSE = 0.002$, $p = .285$, because the total responses were adjusted to equal 1.00 to take into account participants' memory at the initial interview. The effect of response type is present because overall participants made more correct than distorted, $F(1, 44) = 111.26$, $MSE = 0.043$, $p < .0005$, or failed, $F(1, 43) = 136.33$, $MSE = 0.056$, $p < .0005$, responses and because participants made more distorted than failed responses, $F(1, 43) = 7.44$, $MSE = 0.050$, $p = .009$. To understand the interactions between group and response type, information type and response type, and the three-way interaction, separate ANOVAs were performed for each of the response types.

An ANOVA of the correct recall responses revealed effects of information type, $F(1, 44) = 13.39$, $MSE = 0.031$, $p = .001$, and group, $F(2, 44) = 47.67$, $MSE = 0.033$, $p < .0005$, and an interaction between them, $F(2, 44) = 4.33$, $MSE = 0.031$, $p = .019$. To understand the effect of group and the interaction, the ANOVA was repeated with pairs of the groups—AD versus MCI: group, $F(1,30) = 51.49$, $MSE = 0.039$, $p < .0005$, and interaction, $F(1, 30) = 4.02$, $MSE = 0.034$, $p = .054$; AD versus older adults: group, $F(1, 28) = 85.30$, $MSE = 0.032$, $p < .0005$, and interaction, $F(1, 28) = 8.99$, $MSE = 0.028$, $p = .006$; and MCI versus older adults: group, $F(1, 30) = 2.95$, $MSE = 0.029$, $p = .096$, and interaction, $F(1, 30) < 1$. Posthoc analyses also showed that the effect of information type was being driven by the patients with

AD, as indicated by a significant *t* test on information type for this group, $t(14) = 4.31$, $MSE = 0.065$, $p = .001$, but not for the other two: MCI, $t(16) = 1.46$, $MSE = 0.065$, $p = .164$; and older adults, $t(14) < 1$.

An ANOVA of the distorted recall responses for the adjusted data showed effects of information type, $F(1, 44) = 15.97$, $MSE = 0.024$, $p < .0005$, and group, $F(2, 44) = 4.27$, $MSE = 0.032$, $p = .020$, and no interaction, $F(2, 44) = 1.27$, $MSE = 0.024$, $p = .290$. To understand the effect of group, the ANOVA was repeated with pairs of the groups: AD versus MCI, $F(1, 30) = 5.29$, $MSE = 0.039$, $p = .029$; AD versus older adults, $F(1, 28) = 4.59$, $MSE = 0.045$, $p = .041$; and MCI versus older adults, $F(1, 30) < 1$.

An ANOVA of the recall response failures with all three groups revealed effects of group, $F(2, 43) = 13.22$, $MSE = 0.038$, $p < .0005$; information type, $F(1, 43) = 26.22$, $MSE = 0.033$, $p < .0005$; and a Group × Information Type interaction, $F(2, 43) = 5.91$, $MSE = 0.033$, $p = .005$. To understand the effect of group and the interaction, the ANOVA was repeated with pairs of the groups—AD versus MCI: group, $F(1, 29) = 10.57$, $MSE = 0.055$, $p = .003$, and interaction, $F(1, 29) = 5.33$, $MSE = 0.046$, $p = .028$; AD versus older adults: group, $F(1, 27) = 21.70$, $MSE = 0.043$, $p < .0005$, and interaction, $F(1, 27) = 10.04$, $MSE = 0.034$, $p = .004$; and MCI versus older adults: group, $F(1, 30) = 2.94$, $MSE = 0.018$, $p = .097$, and interaction, $F(1, 30) < 1$.

Recognition responses to personal and factual information questions. An ANOVA of the recognition data with group (AD, MCI, older adults) as a between-subjects variable and information type (personal vs. factual) and response type (correct, distorted, failed) as within-subject variables revealed effects of information type, $F(1, 58) = 50.04$, $MSE = 0.002$, $p < .0005$, and response type, $F(2, 116) = 155.78$, $MSE = 0.039$, $p < .0005$, as well as Group × Response Type, $F(4, 116) = 42.02$, $MSE = 0.039$, $p < .0005$; Information Type × Response Type, $F(2, 116) = 45.95$, $MSE = 0.021$, $p < .0005$; and Group × Information Type × Response Type interactions, $F(4, 116) = 9.13$, $MSE = 0.021$, $p < .0005$. As expected, the effect of group and the Group × Information Type interaction were not significant, $Fs(2, 58) = 2.38$, $MSE = 0.002$, $p = .101$, because the total responses were adjusted to equal 1.00 to take into account participants' memory at the initial interview. The effect of response type was present because overall participants made more correct than distorted responses, $F(1, 60) = 174.25$, $MSE = 0.037$, $p < .0005$, or failed responses, $F(1, 58) = 210.88$, $MSE = 0.054$, $p < .0005$, and also because participants made more distorted than failed responses, $F(1, 58) = 30.58$, $MSE = 0.026$, $p < .0005$. To understand the interactions between group and response type, information type and response type, and the three-way interaction, separate ANOVAs were performed for each of the response types.

An ANOVA of the correct recognition responses revealed effects of information type, $F(1, 60) = 15.57$, $MSE = 0.017$, $p < .0005$, and group, $F(2, 60) = 73.34$, $MSE = 0.034$, $p < .0005$, and an interaction between them, $F(2, 60) = 9.53$, $MSE = 0.017$, $p < .0005$. To understand the effect of group and the interaction, the ANOVA was repeated with pairs of the groups—AD versus MCI: group, $F(1, 39) = 53.59$, $MSE = 0.046$, $p < .0005$, interaction, $F(1, 39) = 4.28$, $MSE = 0.019$, $p = .045$; AD versus older adults: group, $F(1, 41) = 191.58$, $MSE = 0.025$, $p < .0005$, interaction, $F(1, 41) = 16.47$, $MSE = 0.011$, $p < .0005$; and MCI versus older adults: group, $F(1, 40) = 9.31$, $MSE = 0.033$, $p = .004$, interaction, $F(1, 40) = 3.59$, $MSE = 0.019$, $p = .065$. Posthoc analyses also showed that the effect of information type was driven by the patients with AD, as indicated by a significant *t* test on information type for this group, $t(20) = 6.61$, $MSE = 0.032$, $p < .0005$, but not for the other two: MCI, $t(19) = 1.63$, $MSE = 0.053$, $p = .120$, and older adults, $t(21) < 1$.

An ANOVA of the distorted recognition responses for the adjusted data showed effects of information type, $F(1, 60) = 74.64$, $MSE = 0.014$, $p < .0005$, and group, $F(2, 60) = 15.76$, $MSE = 0.017$, $p < .0005$, and a Group × Information Type interaction, $F(2, 60) = 5.54$, $MSE = 0.014$, $p = .006$. To understand the effect of group and the interaction, the ANOVA was repeated with pairs of the groups—AD versus MCI: group, $F(1, 39) = 7.93$, $MSE = 0.021$, $p = .008$, interaction, $F(1, 39) = 9.26$, $MSE = 0.015$, $p = .004$; AD versus older adults: group, $F(1, 41) = 33.75$, $MSE = 0.015$, $p < .0005$, interaction, $F(1, 41) = 6.54$, $MSE = 0.014$, $p = .014$; and MCI versus older adults: group, $F(1, 40) = 6.62$, $MSE = 0.013$, $p = .014$, interaction, $F(1, 40) < 1$.

An ANOVA of the recognition response failures with all three groups revealed effects of group, $F(2, 58) = 24.95$, $MSE = 0.030$, $p < .0005$; information type, $F(1, 58) = 61.29$, $MSE = 0.014$, $p < .0005$; and a Group × Information Type interaction, $F(2, 58) = 14.48$, $MSE = 0.014$, $p < .0005$. To understand the effect of group and the interaction, the ANOVA was repeated with pairs of the groups—AD versus MCI: group, $F(1, 37) = 19.98$, $MSE = 0.046$, $p < .0005$, interaction, $F(1, 37) = 11.55$, $MSE = 0.020$, $p = .002$; AD versus older adults: group, $F(1, 39) = 34.66$, $MSE = 0.038$, $p < .0005$, interaction, $F(1, 39) = 23.45$, $MSE = 0.016$, $p < .0005$; and MCI versus older adults: group, $F(1, 40) = 4.21$, $MSE = 0.007$, $p = .047$, interaction, $F(1, 40) = 1.84$, $MSE = 0.006$, $p = .183$.

Discussion

The present study has provided several notable findings. First (and not surprisingly), patients with AD remembered less personal and factual information than patients with MCI and healthy older adults in both the initial interview in the weeks following the event and in the follow-up interview at 3 to 4 months (Tables 1 and 3). Patients with MCI remembered less information than older adults in the recognition but not in the recall analyses (likely because of the greater power of the former relative to the latter) at both time points. Second, in the initial interview all participants remembered more personal details of how they heard the news of the attacks than factual details of those attacks, which is consistent with previous studies (Larsen & Thompson, 1995). This personal versus factual difference was largest, however, in the patients with AD. Third, in the follow-up interview, patients with AD retained more of their personal than factual information, whereas patients with MCI and older adults showed similar retention rates for these two types of information. Fourth, remembering distorted information was relatively common among all participants, more common for personal than factual information, and most common in the patients with AD. Fifth, all participants were more likely to fail to respond to a factual question relative to a personal question, and this difference was largest in patients with AD. Last, patients with

MCI reported lower levels of emotional intensity during the initial interview than did either patients with AD or older adults, who did not differ (Figure 1). Overall, participants also predicted that they would feel less intense about the attacks 1 year in the future relative to their current emotional state.

Focusing first on the emotional intensity results, we found that patients with AD and healthy older adults reported very similar levels of emotional intensity for six common emotions experienced in reaction to the events of September 11, 2001. Our findings are consistent with those of Hamann et al. (2000), who also found that patients with AD showed normal emotional reactions. Several other studies found that patients with AD showed impairments in processing emotional stimuli. However, the authors hypothesized that these impairments were secondary to perceptual and/or cognitive difficulties rather than difficulties in emotional processing per se (Albert et al., 1991; Brosgole et al., 1981; Cadieux & Greve, 1997). Perhaps during an event that occurs outside the laboratory with widespread media coverage, such as the September 11th attacks, perceptual and cognitive deficits related to emotional processing can, to an extent, be overcome.

It is unclear why patients with MCI reported lower levels of emotional intensity compared with both patients with AD and healthy older adults. Although further studies will be necessary to fully explain this finding, we consider one possible explanation. Previous reports have suggested that patients with MCI or very mild AD may show more symptoms of depression than either patients with moderate AD or healthy older adults. For example, Li, Meyer, and Thornby (2001), in a prospective study, found that depressive symptoms among patients with MCI were more persistent than those in patients with AD (whose symptoms showed trends toward decreasing over time). In addition, Zankd and Leipold (2001) found that patients with mild dementia reported more depressive symptoms than those with more severe dementia. It has been hypothesized that depression is more common in individuals with mild versus severe cognitive impairments because those with mild impairments are more aware of their deficits. Supporting this hypothesis, Grut et al. (1993) found that participants' complaints of memory impairment were more common in the milder stages of dementia and that these complaints were positively correlated with depressed mood.

If, as these studies suggest, our patients with MCI were somewhat more depressed than our patients with AD and our healthy older adults, this depressed mood could provide a possible explanation of their diminished emotional intensity relative to the other two groups. First, it may be that patients with a depressed mood are simply more inwardly focused on their own problems and are relatively less emotionally involved in outside issues. Second, studies have shown that individuals with depression show reduced skin conductance responses compared with nondepressed individuals (Argyle, 1991; Ward & Doerr, 1986; Ward, Doerr, & Storrie, 1983). It has also been shown that the degree of skin conductance responses are related to the emotional intensity of those responses (Lanzetta, Cartwright-Smith, & Kleck, 1976). Last, there is also evidence that the sensitivity of the glucocorticoid-receptor—one important factor in stress reactions—is reduced in major depressive disorder (Modell, Yassouridis, Huber, & Holsboer, 1997).

Turning to the memory results, we found that patients with AD were impaired relative to those with MCI and older adults on all aspects of personal and factual information, despite the fact that the groups did not differ in how closely they followed the September 11th media coverage or how much they talked about the attacks. These data therefore support the view that whereas the perceptual and cognitive deficits related to emotional processing in patients with AD may be overcome by extensive review of an event outside the laboratory—allowing patients with AD to report normal emotional intensity—their memory deficits cannot be overcome by this type of reviewing. Thus, we observed a dissociation between intact emotional intensity and impaired memory performance in patients with AD. That patients with MCI—in-between patients with AD and older adults in their memory for personal and factual information—showed less emotional intensity than the other two groups further supports the observed dissociation in this study between emotion and memory.

Focusing next on the differences between memory for personal versus factual information, we found that in the initial interview, all participants remembered more personal details of how they heard the news than factual details of the attacks. This result is consistent with Larsen and Thompson's (1995), who found that for highly memorable events, participants were more likely to accurately locate the day of the week for the personal context surrounding an event than for the core event itself. Larsen and Thompson also found that the vividness of a memory increased the accuracy of locating the day of the week much more for the context (personal circumstances of receiving the news) than for the core (the news event itself).

One particularly interesting finding is that this difference between memory for personal and factual information was greater in the patients with AD than the other groups for both the initial and follow-up interviews. Although this difference may have been attributable to ceiling effects in the older adults on the initial interview (in which their personal information was 100%), ceiling effects were not an issue in the follow-up interview (in which older adults' correct personal information was 75%). Analyses of the follow-up interview demonstrate, in fact, that over the interval between interviews, patients with AD retained more personal versus factual information, whereas patients with MCI and older adults retained the same amount of each of these information types. Combining the results of the initial and follow-up interviews suggests that for patients with MCI and older adults, the enhancement of personal relative to factual information may be attributable solely to the differential initial encoding of the information, whereas in patients with AD this enhancement may also be attributable to increased retention of the personal compared with the factual information.

Although invoking episodic memory deficits may provide an easy explanation as to why the patients with AD remembered less information overall compared with patients with MCI and older adults, it is less clear why patients with AD, but not patients with MCI and older adults, showed preferential retention of personal relative to factual information. This finding is even more surprising when one considers that patients with AD generally show deficits in remembering source information, including remembering the context in which they learned facts, even when they can remember the facts themselves (Bartlett, Halpern, & Dowling, 1995; Multhaup & Balota, 1997; Schacter, Harbluk, & McLachlan, 1984).

One possible explanation for this finding is that the difference observed in the patients with AD between memory for personal versus factual information may be attributable to the relatively greater contribution of the amygdala-based emotional network to personal compared with factual memories. That is, the amygdala may be more involved in the formation of an episodic memory consisting of one's hearing the news of a tragic event compared with learning new semantic information consisting of the details of that event. Consistent with this idea is Mori et al.'s (1999) study of patients with AD who experienced the Kobe earthquake in Japan. Mori et al. found that the volume of the amygdala, but not hippocampus, correlated with the patients' personal memory for the event, whereas neither the amygdala nor hippocampal volume correlated with factual memory of the earthquake.

There are, however, other potential explanations for the difference observed in the patients with AD between their memory for personal versus factual information. For example, it may be that all groups performed more rehearsal of personal than factual information. In the patients with AD, however, the less rehearsed factual information may have decayed rapidly because of these patients' episodic memory deficit. With their intact episodic memory system, older adults—and to a lesser extent patients with MCI—may have been able to remember considerable factual information despite limited rehearsal. Differential effects of rehearsal may thus help explain why patients with AD showed a larger difference between their memory for personal and factual information than for older adults. (It should be noted, however, that this speculation would not be valid if the difference between memory for personal and factual information could be reduced to the difference between emotional and nonemotional episodic memories. First, as mentioned above, Hamann et al., 1997, found that the enhancement of memory for emotionally arousing story elements was the same in amnesic patients and controls. Second, Guy and Cahill, 1999, found that overt rehearsal was insufficient to explain the enhancing effects of emotion on memory.)

Another possibility is that these results are attributable to high confidence in the patients with AD despite their low accuracy. Previous studies of personal memories related to important news events frequently report that participants exhibit high confidence for their memories regardless of the accuracy of those memories (Neisser & Harsch, 1992; Weaver, 1993). In our study, patients with AD reported that they thought they would remember personal information well at both 3 months and 1 year, averaging greater than 4 on a 1- to 5-point scale (Table 2). Thus, although all groups showed fairly high levels of confidence, the patients with AD showed low levels of accuracy even during the initial interview in the first few weeks after the event. Responses that stayed the same from the initial to the follow-up interviews may then reflect response tendencies (guesses) rather than retention of true memories. Although we attempted to compensate for this possibility by correcting initial and follow-up interviews for verified responses as described above, it may be that the compensation was incomplete.

Overly high confidence leading to liberal response biases may also explain the high level of memory distortions observed among all participants; indeed, memory distortions were considerably higher than response failures ("I don't know" responses). Similarly, if participants believed they were more likely to remember personal than factual information, this belief may also explain why memory distortions were greater for the personal versus the factual questions. These findings are consistent with other studies that have found high levels of memory distortions of personal information related to a news event (Bohannon & Symons, 1992; Finkenauer et al., 1998; Neisser & Harsch, 1992). If patients with AD showed almost as high a confidence for their responses compared with the other groups despite the fact that their accuracy was considerably lower, this discrepancy could explain their higher level of memory distortions relative to the other groups. Although most research into the memory of patients with AD has focused on their failure to retrieve desired information (Lezak, 1995; Morris, 1996), several laboratory studies have shown that these patients may exhibit greater memory distortions relative to older adults (Balota et al., 1999; Budson, Daffner, Desikan, & Schacter, 2000). Our study suggests that, outside of the laboratory, distortions of memory in patients with AD for personal information may be more common than previously suspected.

It is worth noting that our study shows some similarities to studies of flashbulb memories. R. Brown and Kulik (1977) proposed the term *flashbulb memory* to capture the perceived seemingly photographic quality of personal memories related to previous national traumatic events such as the assassination of President John F. Kennedy. R. Brown and Kulik postulated a specific physiological mechanism involving event novelty, personal importance–emotional arousal (consequentiality), and rehearsal to explain why these memories should be more vivid than others. Later researchers have proposed alternatives to this model, focusing on the relative weights and relationship between these different aspects of the event (Christianson, 1989; Conway et al., 1994; Finkenauer et al., 1998). In a study of younger and older adults, Cohen, Conway, and Maylor (1994) found that older adults were less able than young adults to form flashbulb memories related to the resignation of the British Prime Minister Margaret Thatcher: Whereas 90% of young adults were able to generate flashbulb memories, only 42% of older adults were able to do so. Cohen et al. (1994) concluded that the inability of the majority of the older adults to form flashbulb memories was attributable to deficits in their memory for source and context. Because we did not directly assess surprise and personal consequentiality, two important aspects of flashbulb memories, our study may not have met the original criteria for a flashbulb memory. Nevertheless, we did measure "shock," which was very high in all participants (see Figure 1). Furthermore, it has been observed that many Americans with no personal connection to the events experienced symptoms of stress related to the attacks (Schuster et al., 2001). We believe that for Americans there has not been a more surprising or consequential national news event since the assassination of John F. Kennedy, if not since the last attack on American soil in Pearl Harbor. Thus, we also believe it likely that our participants had the opportunity to form flashbulb memories.

Leaving aside the controversy over whether flashbulb memories are fundamentally different than ordinary episodic memories, we performed an additional analysis with our data in an attempt to ascertain if our participants formed flashbulb memories using similar (though not identical) criteria as in Cohen, Conway, and Maylor (1994). In Cohen et al.'s study they determined that a participant had a flashbulb memory if they scored 9 or 10 out of 10 on a scale made up of five memory attributes (description, people, place, activity, and source), which were each scored 0 (*forgot* or *different response*), 1 (*basically but not exactly correct response*), or 2 (*exactly correct response*). We created a similar scale using our Questions 2 through 6 (time, people, place, activity, and source), which were each scored either 0 (*forgot* or *different* *response*) or 1 (*basically or exactly correct response*). ("Time" was substituted for "description" because only specific questions were considered in the present study, and only 0 and 1 were used in scoring because in our scoring scheme an answer was either correct or not. Thus, our analysis is not directly analogous with that of Cohen et al.'s.) Figure 2 shows what percentage of participants answered zero, one, two, three, four, or all five of these questions correctly at the follow-up interview relative to the initial one. If we use the strict criterion that all five questions must be answered correctly, 53% (recall) and 50% (recognition) of our older adults were able to form flashbulb memories, comparable with the 42% observed in the older adults in Cohen's study. Similar numbers of our patients with MCI formed flashbulb memories—MCI versus older adults: recall, $F(1, 30) < 1$, and recognition, $F(1, 40) < 1$—whereas almost no patients with AD formed flashbulb memories—AD versus MCI: recall, $F(1, 30) = 15.82$, $MSE = 0.141$, $p < .0005$, and recognition, $F(1, 39) = 10.96$, $MSE = 0.151$, $p = .002$; and AD versus older adults: recall, $F(1, 28) = 16.00$, $MSE = 0.133$, $p < .0005$, and recognition, $F(1, 41) = 13.97$, $MSE = 0.157$, $p = .001$. In brief, we conclude that, within the limits of the present study, our patients with AD were not able to form flashbulb memories, whereas roughly half of our older adults and our patients with MCI were able to do so.

Several features of our study could be improved on in future observational studies of this type. First, we did not verify the responses of our memory-impaired participants at the time of their initial interview. Second, we did not directly assess surprise and personal consequentiality, which are important to make our results comparable with those of studies of flashbulb memories. Third, we did not include memory for a nonemotional control event to compare with the memory of the September 11th attacks. This lack of a control event hinders comparisons with laboratory studies in addition to constraining our present conclusions. One possibility would be to use the actual phone call of the experimenter to the participant as the nonemotional event. Using this phone call has several advantages, including that all participants will have experienced a fairly similar event and that the personal and factual information reported regarding this event will likely be accurate and will be relatively easy to verify.

In closing, we return to the questions posed in the introduction, summarizing our results in answering these questions. First, we found that patients with AD and healthy older adults reported similar levels of emotional intensity to a real-world event outside the laboratory, whereas patients with MCI reported somewhat less intensity, particularly for anger and fear. Next, we found that patients with AD remembered less personal and less factual information than patients with MCI and older adults in both the initial and follow-up interviews. Patients with AD retained relatively more of their personal compared with factual information from the first to the second interview, whereas patients with MCI and older adults retained similar levels of these two types of information. Last, we found that patients with AD showed more memory distortions than patients with MCI and older adults, which may be attributable to the liberal response bias seen in the patients with AD. Our study suggests that distortions of memory in patients with AD for real-world events may be more common than previously suspected and that such distortions may be in part related to the

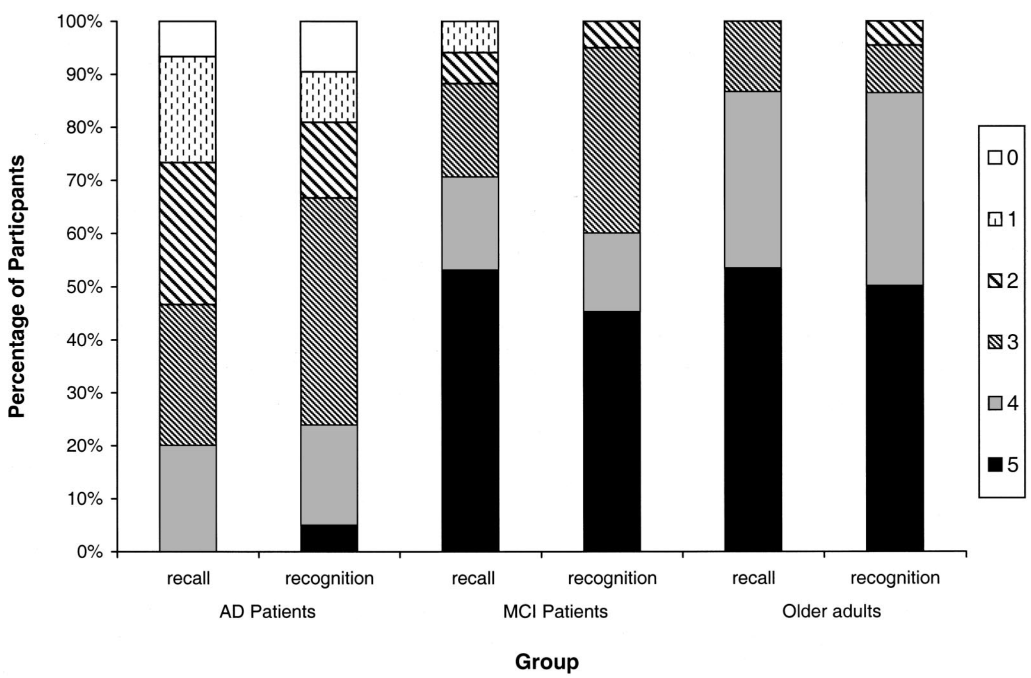

Figure 2. Percentage of participants who answered one, two, three, four, or five personal information questions (time, people, place, activity, and source; for Questions 2–6, see the text of article and Appendix B, which is available on the Web at http://dx.doi.org/10.1037/0894-4105.18.2.315.supp) correctly at the follow-up interview relative to the initial one as a function of group (patients with Alzheimer's disease [AD] and mild cognitive impairment [MCI] and older adults) and response type (recall vs. recognition).

patients' disproportionate confidence in their memory relative to their degree of memory impairment.

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Appendix

Typical Examples of Distorted Responses

"What were you doing when you first heard the news of the attacks?"

> 1st response: "had just gone to do some errands and was bringing things inside."
> 2nd response: "was getting up and getting organized."

"How did you first learn about the attacks?"

> 1st response: "overheard 2 women talking."
> 2nd response: "saw it on TV."

Where were you when you first heard about the attacks?"

> 1st response: "outside."
> 2nd response: "at home."

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