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MEMORY FOR THE SEPTEMBER 11, 2001, TERRORIST ATTACKS ONE YEAR LATER IN PATIENTS WITH ALZHEIMER'S DISEASE, PATIENTS WITH MILD COGNITIVE IMPAIRMENT, AND HEALTHY OLDER ADULTS

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ABSTRACT

Although there are many opportunities to study memory in patients with Alzheimer's disease (AD) in the laboratory, there are few opportunities to study memory for real world events in these patients. The September 11, 2001 terrorist attacks provided one such opportunity. Patients with AD, patients with mild cognitive impairment (MCI), and healthy older adults were given a telephone questionnaire in the initial weeks after the event, again three to four months later, and finally one year afterwards to evaluate their memory for the September 11, 2001 terrorist attacks. We were particularly interested in using the attacks as an opportunity to examine the decline of episodic memory in patients with AD, patients with MCI, and older adult controls over a period of months. We found that compared to healthy older adults, patients with AD and MCI showed impaired memory at the initial time point, more rapid forgetting from the initial to the three-month time point, and very similar changes in memory from the three-month to the one-year time point. We speculated that these findings were consistent with patients with AD and MCI showing initial impaired encoding and a more rapid rate of forgetting compared with healthy older adults, but that once the memories had been consolidated, their decay rate became similar to that of healthy older adults. Lastly, although memory distortions were common among all groups, they were greatest in the patients with AD.

Key words: flashbulb memory, episodic memory, false memory

Understanding the precise nature of the episodic memory impairment in patients with Alzheimer's disease (AD) has been a topic of intense debate for over twenty years (Kopelman, 1985). Although many researchers attribute the impairment in episodic memory to defective encoding (e.g., Greene et al., 1996; Degenszajn et al., 2001), others attribute it to an accelerated rate of forgetting attributable to impaired storage (e.g., McBride et al., 2002; Vanderploe et al., 2001). Most researchers who have studied the decay of memory in AD have looked over periods of minutes or hours. One study examined memory over three intervals including 24 hours and 7 days (Kopelman, 1985). All previous studies have examined memory for laboratory stimuli. In the present study we used memory for the September 11, 2001 terrorist attacks to examine the decay of memory of emotional and consequential events outside of the laboratory in patients with AD, patients with MCI, and older adults over a period of months.

The reason that the decay of episodic memory over longer periods of time, such as months, has never been investigated in either patients with AD or MCI is relatively simple; there are few if any laboratory stimuli that are sufficiently salient to engender memory over such long periods of time. The September 11, 2001 terrorist attacks provided an opportunity to study memory for a national public event, an event that would be sufficiently salient to engender memory over months and years, if not a lifetime. As President George W. Bush stated after the attacks of September 11, 2001, "None of us will ever forget this day" (Bush, 2001). But is the President's statement correct for patients with AD and patients with MCI? Or would their memory for September 11th degrade to nothing over the course of a year? In the present study we hope to provide an answer to this question.

Previous studies using laboratory stimuli to examine episodic memory over time in patients with AD have been split between those who found the rate of forgetting to be similar to controls – leading to the hypothesis that defective encoding is their major memory impairment, and those who found an accelerated rate of forgetting compared to controls – leading to the hypothesis that defective storage is their major memory impairment.

Kopelman (1985) found that patients with AD showed an initial deficit in encoding; their memory then decayed at the same rate as the healthy controls over 10 minutes, 24 hours, and 7 days.

Other studies also found defective encoding and then a similar forgetting rate compared with controls. Degenszajn et al. (2001) found that patients with mild to moderate AD and matched controls showed a similar rate of forgetting at 30 minutes and 24 hours after learning. Greene et al. (1996) found impaired learning and not accelerated forgetting as the cause of the patients' impairment compared with controls on the Doors and People test. White and Ruske (2002) examined forgetting curves in AD and found that patients with AD differed from controls in their encoding (their initial discriminability) and not their rate of forgetting.

By contrast, Reed et al. (1998) compared recognition in patients with AD and controls with a delay of 10 minutes relative to a learning baseline of 10 seconds. They found that the delayed recognition ratio was lower in the patients relative to controls, and concluded that forgetting is accelerated in AD because of impaired storage and other aspects of memory processing. McBride et al. (2002) found that a more rapid rate of forgetting of verbal material differentiated patients with AD from both controls and elderly patients with schizophrenia. Vanderploe et al. (2001) compared patients with AD to those with cortical and subcortical vascular dementia; they found that rapid forgetting was unique to AD.

Some studies have found mixed results. Using data from the Consortium to Establish a Registry for Alzheimer's Disease (CERAD) word list memory test (Morris et al., 1989), Moulin et al. (2004) found that patients with AD showed deficits in both acquisition and consolidation compared with controls. Christensen et al. (1998) found that rates of forgetting were similar between patients with AD and controls for picture and word recognition, design recognition, and stem completion. But in a picture recall task, faster rates of forgetting were observed in the patients relative to controls. Grober and Kawas (1997) examined participants in the Baltimore Longitudinal Study of Aging to investigate learning and retention in patients with preclinical AD (those who converted to AD over 3 years) and patients with early AD. They found that those with preclinical AD showed an impairment of learning but their retention (forgetting) rate was identical to controls. Patients with early AD, however, showed a retention deficit; that is, they showed a rapid rate of forgetting.

During the years of this debate, symptomatic treatments for AD have been approved for use in the United States and other countries (Tariot et al., 2004; Rogers et al., 1996; Raskind et al., 2000), and disease modifying treatments are being developed. The development of treatment for AD has dramatically increased the interest in early diagnosis. Because of this, research on mild cognitive impairment (MCI), a pre-Alzheimer's state, has become of great interest (Petersen et al., 2001). Patients with MCI, amnestic type, are those individuals who show an isolated memory impairment, are otherwise functioning well, and do not meet criteria for AD or other dementia. The cognitive neuropsychology of the episodic memory deficit in patients with MCI has recently begun to be investigated. Wang and Zhou (2002) compared patients with MCI with controls and found that patients with MCI showed both impairment in encoding and retrieval of episodic memory (storage decay was not separately examined). Chetelat et al. (2003) also found deficits of both encoding and retrieval in patients with MCI; further they found that whereas both deficits correlated with declines in hippocampal density on structural imaging, encoding but not retrieval also correlated with hippocampal activation on positron emission tomography (PET) imaging. Moulin et al. (2004) found that patients with MCI showed deficits in both acquisition and consolidation compared with controls. No studies, however, have looked specifically at the rate of decline of episodic memory in patients with MCI.

We used telephone interviews to examine memory for the September 11, 2001 terrorist attacks in patients with AD, patients with MCI, and healthy older adult controls in the weeks following the attacks (9/19/2001-10/02/2001), again approximately three to four months later (12/11/2001-1/17/2002), and finally at approximately 1 year (8/7/2002-9/10/2002; median 8/13/02) (Note that we interviewed participants prior to September 11, 2002, so as to reduce contamination of their responses with anniversary news media presentations). We have previously reported data for the first two time points (Budson et al., 2004). In the present study we have used the data from all three time points to examine the decay of memory over time in these different participant groups. As previously, we report memory for two different types of information. We first report their memory for how they personally heard the news of the attacks; this *personal information* is similar to the "personal reception context" of Larsen, Brown and their colleagues (Brown et al., 1985; Larsen, 1988; Larsen and Thompson, 1995). Next we report their memory for the factual details of the events of September 11th; this *factual information* is similar to the "news" or "core event" of Larsen, Brown, and their colleagues (Brown et al., 1985; Larsen, 1988; Larsen and Thompson, 1995).

Materials and Methods

Participants

The study began with 23 healthy older adults, 21 patients with MCI (Petersen et al., 2001), and 22 patients with probable AD [NINCDS-ADRDA

(National Institute of Neurological and Communicative Diseases and Stroke-Alzheimer's Disease and Related Disorders Association) criteria used; McKhann et al., 1984]. At the third time point, 22 healthy older adults, 19 patients with MCI, and 14 patients with AD were available for the telephone interview, and therefore only data from these participants are able to be included in the present study. Patients with AD and MCI were recruited from the clinical population at the Memory Disorders Unit, Brigham and Women's Hospital, Boston, MA, USA. 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, as well as from flyers and posters placed in senior centers in and around Boston. Oral informed consent was obtained from all participants and their care-givers (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 roughly matched on the basis of gender (AD: 7 male and 7 female; MCI: 11 male and 8 female; older adult: 9 male and 13 female), age (AD mean = 77.6 years, range = 68-90; MCI mean = 74.7 years, range = 54-88; older adult mean = 76.0 years, range = 64-89), and education (AD mean = 14.4 years, range = 11-20; MCI mean = 15.0 years, range = 8-23; older adults mean = 14.1 years, range = 8-20). Patients with AD were in the mild-to-moderate stages of disease; mini-mental status examinations (MMSE; Folstein et al., 1975) obtained within a year of their initial interview had a mean of 21.9 and ranged from 16 to 26. Recall data from 3 patients with AD, 3 patients with MCI, and 7 older adults were not recorded at the first time point due to experimenter error, and were thus excluded from the recall analyses.

Questionnaire

Design

The questionnaires were loosely based upon a previously used questionnaire (Schmolck et al., 2000) and were developed jointly by the 9/11 Memory Consortium (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, and 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 of Budson et al. (2004), available on line at *http://dx.doi.org/10.1037/0894-4105.18.2.315.supp*. The first questionnaire used in the present study can be found in Appendix B of Budson et al. (2004), available on line at *http://dx.doi.org/10.1037/0894-4105.18.2.315.supp*; the second and third were virtually identical with the exception of some minor changes in wording.

The questionnaire has been previously described in detail (see Budson et al., 2004). Aspects of the questionnaire relevant for the present study are described here. Thirteen questions (2-12, 27, part of 29) concerned memory for personal information, such as "Where were you when you first became aware of the attack?". Six questions (22-26, part of 29) concerned memory for factual information, such as "How many airplanes were involved in the attack?". Three questions concerned the extent to which participants reviewed the events of September 11th (20, 21, 37), and two questions concerned how well participants predicted they would remember their personal information (12.1, 12.2). 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.

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 can be found in Appendix C of Budson et al. (2004), available on line 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 upon request. Briefly, 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 non-response. Verification of the accuracy of the patients' personal information responses was performed post-hoc as described below under *Verified Responses*. Factual information questions were scored both for the presence of recall and recognition responses and for the accuracy of those responses (accurate scored as 1, inaccurate and

non-responses scored as 0). Some of these questions (8, 23-25, 29) necessitated multiple answers and were thus 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. Questions 20 and 21 (reviewing the events of September 11th were scored on a five-point scale (1 low, 5 high). See *Results* section for scoring and analyses of the follow-up interviews. A brief summary of the scoring of distortions can be found below.

Distorted Responses

For the recognition responses, a response was considered a distortion if a different response was chosen by the participant (see Appendix B of Budson et al., 2004, available on line at *http://dx.doi.org/10.1037/0894-4105.18.2.315.supp* for the various recognition responses available). For the majority of the recall responses, the data were converted into a recognition response first, and then treated in the same manner as the recognition responses. For example, if a participant first stated she was with "her friends Sally, Joe, and Sam" and later stated she was with "friends", because both of these responses would be converted into the recognition response "FRIEND", the response would be scored as correct. If instead she stated she was with her husband at the follow-up interview, this response would be converted into the recognition response "RELATIVE" and would thus be scored as a distortion. The rare exception to these general rules is that if on the follow-up interview she stated she was with "her friends Sally, Joe, and Burt" (and not Sam) this response would be treated as a distortion because the specifics had been altered.

Verified Responses

We performed post-hoc analyses in an effort to confirm the patients' personal responses. Of the 15 questions that constitute the personal information section (2-12, 27, part of 29, see Appendix B), 6 of these questions (2-time heard, 3-source of information, 4-where you were, 6-who else was there, 11-personal losses suffered, 12-inconvenience incurred) would be reasonably likely to be the same for both the patient and their healthy spouse. Twelve of the initial 22 patients with AD and 3 of the 21 initial patients with MCI had a spouse who also performed the study and was thus 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 with unverified responses; no differences were present [Fs (1, 20) < 1]. We therefore 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 were 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 interviews, reducing their correct responses and increasing 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 9/19/01 to 10/02/01. A script approved by the IRB 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, recording 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. For the follow-up interviews at 3 months and 1 year the participants were called by telephone from 12/11/01 to 1/17/02, and again from 8/7/2002 to 9/10/2002. Very similar procedures were followed for these follow-up interviews.

Results

We began by analyzing how much each group, patients with AD, patients with MCI, and older adults, reported that they reviewed the attacks over the last year (Table I). Next we analyzed the change in the proportion of correct responses from

TABLE I

Review of the attacks over the last year in patients with AD, patients with MCI, and Older adults

Question		AD	MCI	Older adults
20	How closely did you follow the media coverage?	3.54	4.21	4.55
21	How much have you talked about the attack since the announcement?	3.36	3.42	4.09

Note. Responses were based on a 1 (very little) to 5 (very much) point scale. AD = Alzheimer's disease; MCI = mild cognitive impairment.

the initial time point to the three-month time point, for recall and recognition of personal and factual information. Lastly we analyzed the change in the proportion of responses from the three-month to the one-year time points.

Table II shows the raw data: the averages of the responses to the personal and factual information as a function of group (patients with AD, patients with MCI, and older adults), response mode (recall *vs.* recognition), and time point (initial, 3 month, and 1 year). For example, the personal information consisted of 13 questions; if a participant provided answers 10 of those questions, reporting "I don't remember" (or the equivalent) for the other 3, their average would equal 10/13 or .77. For the personal data, all initial responses were scored as correct, with the exception of the AD data, as discussed below. For the factual data, initial responses were scored as either correct or distorted (incorrect) depending upon the accuracy of those responses. For the three-month and one-year time points, we analyzed what had become of participants' initial interview responses. Initial responses were divided into correct responses, distorted responses (changed or incorrect, see Materials and Methods for examples), and response failures ('I don't know' or the equivalent). 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 II but not analyzed. The sum of these components thus equals the initial interview responses.

Table II also shows the data after the verification factors for personal information were applied to the data for the patients with AD. As discussed above in the *Methods*, these factors reduced correct responses and increased distorted responses of the personal information in the patients with AD. Since verified personal information are being analyzed, 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.

We then adjusted the data such that three components would equal 1.00 in order 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 and 1 year retention intervals, rather than simply

TABLE II

Memory for Personal and Factual Information at 3 months and 1 year, unadjusted data

	AD – Unverified			AD			MCI			Older adults		
	initial	3 mo	1 yr	Initial	3 mo	1 yr	Initial	3 mo	1 yr	Initial	3 mo	1 yr
Personal Recall												
Correct	.89	.53	.45	.74	.43	.38	.97	.68	.65	1.00	.74	.72
Distortion	–	.29	.24	.15	.38	.32	–	.25	.27	–	.25	.25
Failure	–	.07	.19	–	.07	.19	–	.05	.05	–	.02	.04
Total	.89	.89	.89	.89	.89	.89	.97	.97	.97	1.00	1.00	1.00
Personal Recognition												
Correct	.93	.51	.53	.76	.41	.43	.98	.66	.65	1.00	.75	.73
Distortion	–	.35	.27	.17	.45	.36	–	.30	.29	–	.25	.25
Failure	–	.08	.14	–	.08	.14	–	.02	.05	–	.06	.02
Total	.93	.93	.93	.93	.93	.93	.98	.98	.98	1.00	1.00	1.00
Factual Recall												
Correct				.14	.08	.01	.55	.46	.34	.68	.58	.51
Distortion				.17	.08	.07	.13	.11	.10	.13	.14	.11
Failure				–	.11	.22	–	.07	.14	–	.07	.12
Improvement				–	.02	.02	–	.04	.05	–	.03	.06
Total				.31	.31	.31	.68	.68	.68	.81	.81	.81
Factual Recognition												
Correct				.23	.12	.06	.57	.46	.37	.74	.64	.55
Distortion				.27	.13	.11	.14	.12	.12	.09	.08	.12
Failure				–	.18	.26	–	.07	.13	–	.06	.10
Improvement				–	.05	.03	–	.03	.03	–	.02	.03
Total				.50	.50	.50	.71	.71	.71	.83	.83	.83

Note. Total refers to the proportion of responses at the initial interview. AD = Alzheimer's disease, MCI = mild cognitive impairment.

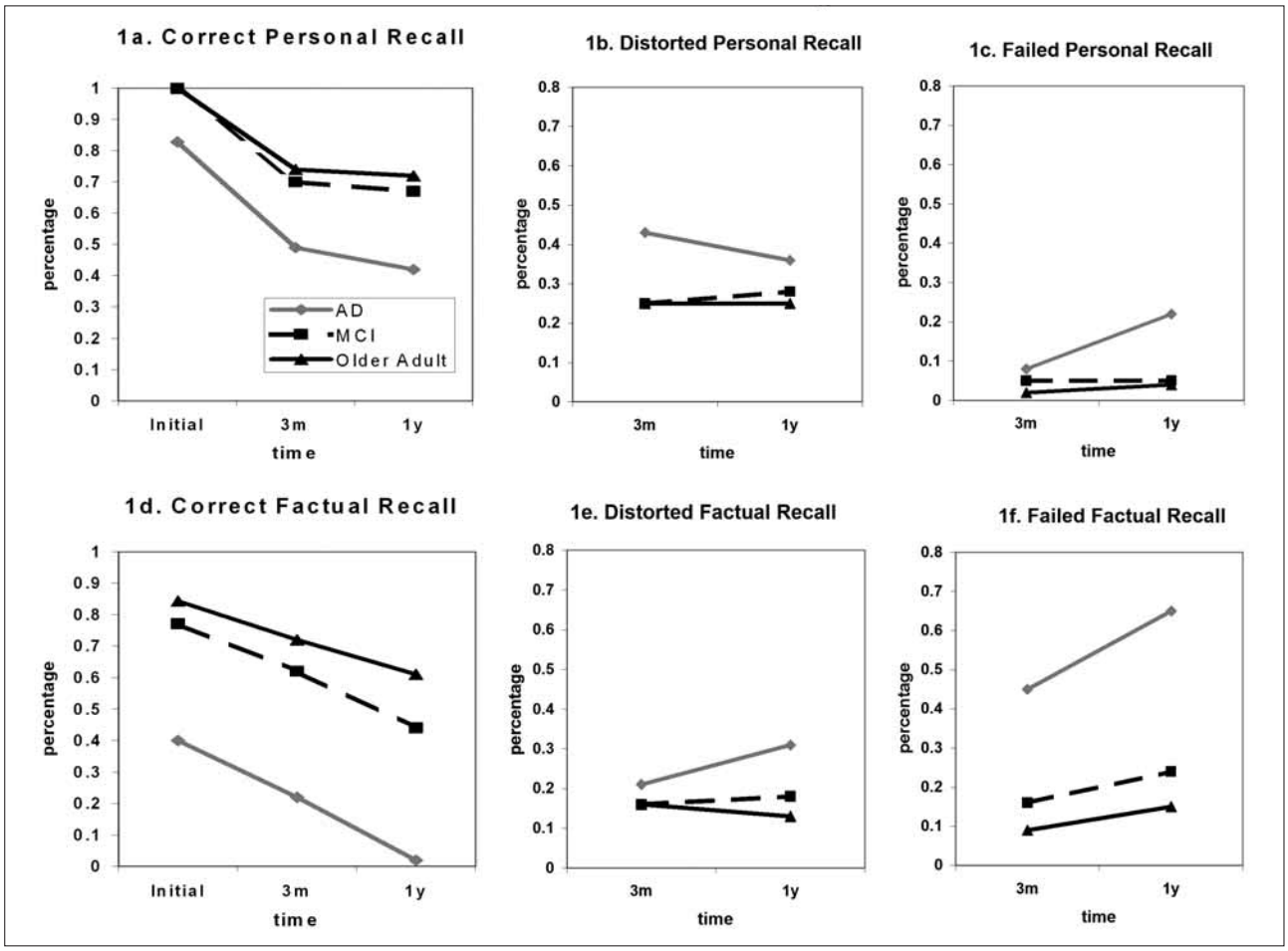

Fig. 1 – *Adjusted recall data for personal and factual information in patients with AD (AD), patients with MCI (MCI), and older adult controls (Older adult) showing correct, distorted, and failed responses.*

reflecting memory differences at the initial time point. The adjusted data is shown in Figures 1 and 2 for recall and recognition, respectively.

The results analyzed were very similar between verified and unverified responses, and also between unadjusted and adjusted responses. Because we believe that the adjusted and verified data is the most accurate reflection of how participants' responses changed from the initial to the follow-up interview, these analyses are presented. After initial overall analyses, separate planned analyses are performed for each of the Responses Types (correct, distorted, failed) for personal and factual information. In these separate analyses, the effect of Group will inform us regarding overall group differences collapsed across the two time points, the effect of Time will inform us regarding overall differences between the two time points collapsed across the groups, and the Group × Time interaction will inform us as to whether the change over time (i.e., the slope of the change) is similar or different between groups. Because the number of subjects analyzed is relatively small, effect sizes are presented as η^2. η^2 indicates the proportion of the variance of the data that can be explained by the effect or interaction (Rosenthal and Rosnow, 1991). Finally, to enhance readability of Table II and the figures, within-group variation is reported as the mean square error (MSE) in the text of the results below, rather than as standard deviation or standard error in the tables, or error bars in the figures. All statistical analyses were performed using SPSS 10.05 or 15.0 (SPSS Inc., Chicago, IL, USA).

Review of the Attacks

A repeated-measures analysis of variance (ANOVA) for questions 20 and 21 regarding how much the groups (AD, MCI, and older adults) reviewed the attacks over the last year revealed effects of Question [$F(1, 52) = 6.37$, MSE = .937, $p = .015$, $\eta^2 = .11$], Group [$F(2, 52) = 4.09$, MSE = 1.669, $p = .022$, $\eta^2 = .14$] and no interaction [$F(2, 52) < 1$, $\eta^2 = .03$]. The effect of Question indicates that overall participants responded that over the last year they followed the media coverage more than they talked about the attacks. Pairwise comparisons show that the effect of Group is present because patients with AD reviewed the attacks less than older adults ($p = .007$) and patients with MCI showed a weak trend towards having reviewed the attacks less than older adults ($p = .085$); there was no significant

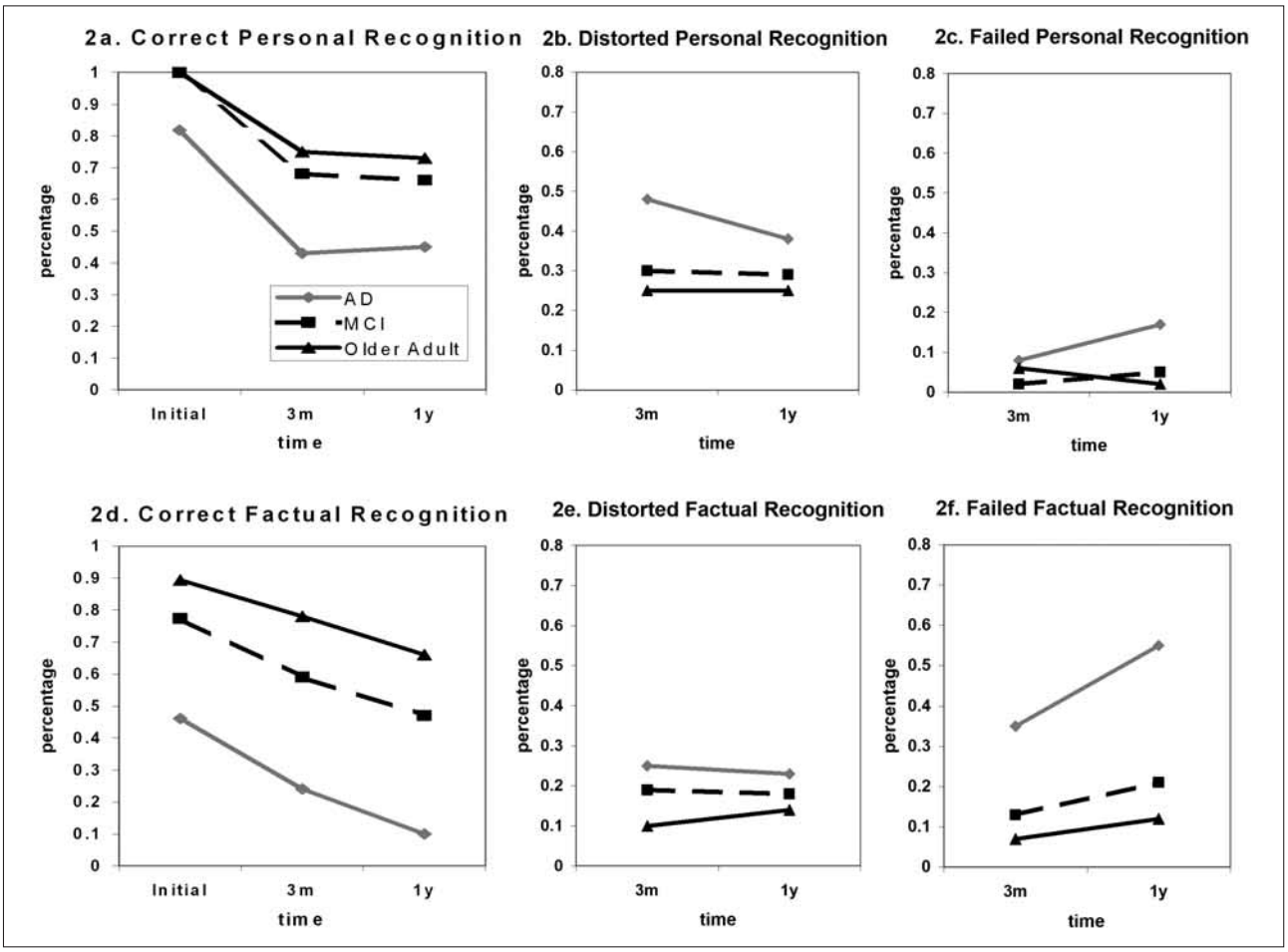

Fig. 2 – *Adjusted recognition data for personal and factual information in patients with AD (AD), patients with MCI (MCI), and older adult controls (Older adult) showing correct, distorted, and failed responses.*

difference between patients with AD and patients with MCI ($p = .256$).

Initial vs. 3-Month Recall Correct Responses

An ANOVA of the recall data with Group (AD, MCI, older adults) as a between-subjects variable and Time (initial *vs.* 3 months) and Information Type (personal *vs.* factual) as within-subjects variables for correct responses revealed effects of Time [$F (1, 39) = 260.01$, $MSE = .008$, $p < .0005$, $\eta^2 = .87$], Information Type [$F (1, 39) = 36.00$, $MSE = .045$, $p < .0005$, $\eta^2 = .48$], and Group [$F (2, 39) = 36.68$, $MSE = .045$, $p < .0005$, $\eta^2 = .65$], and interactions between Information Type × Group [$F (2, 39) = 4.97$, $MSE = .045$, $p = .012$, $\eta^2 = .20$], and Time × Information Type [$F (1, 39) = 19.54$, $MSE = .0005$, $p < .0005$, $\eta^2 = .33$]. There were no reliable interactions of Time × Group [$F (2, 39) = 1.76$, $MSE = .008$, $p = .185$, $\eta^2 = .08$] or Time × Information Type × Group [$F (2, 39) < .1$, $\eta^2 < .01$]. The effect of Time is present because the proportion of correct recall responses was greater at the initial than at the 3-month time point (Table II and Figure 1a). The effect of Information Type is present because participants made more correct recall responses for personal than factual information. The effect of Group is present because patients with AD made fewer correct recall responses than patients with MCI ($p < .0005$) and older adults ($p < .0005$); patients with MCI did not differ significantly from older adults ($p = .173$). The interaction between Information Type and Group is likely present because the effect of Information Type showed a larger effect size for patients with AD [$F (1, 10) = 22.69$, $MSE = .059$, $p = .001$, $\eta^2 = .69$] than for either patients with MCI [$F (1, 15) = 7.59$, $MSE = .051$, $p = .015$, $\eta^2 = .34$] or older adults [$F (1, 14) = 4.45$, $MSE = .027$, $p = .053$, $\eta^2 = .24$]. The interaction between Time and Information Type is likely attributable to the fact that that the effect size was larger for the decline over Time for personal [$F (1, 39) = 195.59$, $MSE = .009$, $p < .0005$, $\eta^2 = .83$] than for factual [$F (1, 39) = 49.76$, $MSE = .010$, $p < .0005$, $\eta^2 = .56$] information.

Initial vs. 3-Month Recognition Correct Responses

An ANOVA of the recognition data with Group (AD, MCI, older adults) as a between-subjects variable and Time (initial *vs.* 3 months) and Information Type (personal *vs.* factual) as within-subjects variables for correct responses revealed effects of Time [$F (1, 52) = 341.98$, $MSE = .010$, $p <$

.0005, η^2 = .87], Information Type [F (1, 52) = 57.99, MSE = .022, p < .0005, η^2 = .53], and Group [F (2, 52) = 66.59, MSE = .035, p < .0005, η^2 = .72], and interactions between Time × Group [F (2, 52) = 6.70, MSE = .010, p = .003, η^2 = .21], Information Type × Group [F (2, 52) = 10.85, MSE = .022, p < .0005, η^2 = .29], and Time × Information Type [F (1, 52) = 46.47, MSE = .006, p < .0005, η^2 = .47]. There was no three-way interaction [F (2, 52) < 1, η^2 < .01]. The effect of Time is present because the proportion of correct recognition responses was greater at the initial than at the 3-month time point (Table II and Figure 2a). The effect of Information Type is present because participants made more correct recognition responses for personal than factual information. The effect of Group is present because patients with AD made fewer correct recognition responses than patients with MCI (p < .0005), who in turn made fewer recognition responses than older adults (p = .002). The interaction between Information Type and Group is likely present because the effect of Information Type showed a larger effect size for patients with AD [F (1, 10) = 22.69, MSE = .059, p = .001, η^2 = .69] than for either patients with MCI [F (1, 15) = 7.59, MSE = .051, p = .015, η^2 = .34] or older adults [F (1, 14) = 4.45, MSE = .027, p = .053, η^2 = .24]. The interaction between Time and Group is likely attributable to the mean difference between the initial and three-month time points being greatest in the patients with AD [.64 – .34 = .30; F (1, 13) = 123.52, MSE = .010, p < .0005, η^2 = .91], followed by the patients with MCI [.89 – .63 = .26; F (1, 18) = 89.71, MSE = .014, p < .0005, η^2 = .83], and least in the older adults [.95 – .76 = .19; F (1, 21) = 139.62, MSE = .005, p < .0005, η^2 = .87]. The interaction between Information Type and Group is likely attributable to the effect size of Information Type being larger for patients with AD [F (1, 13) = 50.50, MSE = .021, p < .0005, η^2 = .80] than for patients with MCI [F (1, 18) = 12.04, MSE = .037, p = .003, η^2 = .40] and older adults [F (1, 21) = 3.28, MSE = .010, p = .085, η^2 = .14]. The interaction between Time and Information Type is likely attributable to the fact that that the effect size is larger for the decline over Time for personal [F (1, 52) = 335.52, MSE = .008, p < .0005, η^2 = .87] than for factual [F (1, 52) = 107.90, MSE = .007, p < .0005, η^2 = .68] information.

3-Month vs. 1-Year Recall Responses

Overall Analysis

An ANOVA of the recall data with Group (AD, MCI, older adults) as a between-subjects variable and Time (3 months *vs.* 1 year), Information Type (personal *vs.* factual), and Response Type (correct, distorted, failed) as within-subjects variables revealed effects of Information Type [F (1, 39) = 44.93, MSE = .0021, p < .0005, η^2 = .54] and Response Type [F (2, 78) = 98.85, MSE = .0593, p < .0005, η^2 = .71]. There were interactions of Time × Group [F (2, 39) = 4.37, MSE = .0024, p = .019, η^2 = .18], Response Type × Group [F (4, 78) = 30.14, MSE = .0593, p < .0005, η^2 = .61], Time × Information Type × Group [F (2, 39) = 4.73, MSE = .0024, p = .014, η^2 = .20], Time × Response Type [F (2, 78) = 12.15, MSE = .0275, p < .0005, η^2 = .24], Information Type × Response Type [F (2, 78) = 37.94, MSE = .0485, p < .0005, η^2 = .49], and Information Type × Response Type × Group [F (4, 78) = 5.65, MSE = .0485, p < .0005, η^2 = .23]. The Time × Information Type × Response Type was marginally significant [F (2, 78) = 3.06, MSE = .0341, p = .052, η^2 = .07].

There was no overall effect of Time [F (1, 39) < .1, η^2 < .01] or Group [F (2, 39) = 1.08, MSE = .0022, p = .349, η^2 = .05]. There were no interactions between Information Type × Group [F (2, 39) < 1, η^2 = .04], Time × Information Type [F (1, 39) < 1, η^2 = .07], Time × Response Type × Group [F (4, 78) = 1.46, MSE = .0275, p = .223, η^2 = .07], or Time × Information Type × Response Type × Group [F (4, 78) < 1, η^2 = .02].

The effect of Information Type was present because overall participants made more initial responses to personal than factual questions. The effect of Response Type indicated that overall participants made differing numbers of correct, distorted, and failed responses. The Time × Group interaction indicated that change in the variables over time was different between the groups. The Response Type × Group interaction indicated that the groups made different numbers of responses to the different response types. The Time × Information Type × Group interaction indicates that the change over time in personal and factual information differed between the groups. The Time × Response Type interaction indicates that the proportion of correct, distorted, and failed responses changed over time. The Information Type × Response Type interaction indicates that the proportion of correct, distorted, and failed responses were different for the personal *versus* the factual information. The Information Type × Response Type × Group interaction indicates that the proportion of correct, distorted, and failed responses were different for the personal *versus* the factual information among the different groups. To understand the three-way interactions between Time × Information Type × Group and Information Type × Response Type × Group separate analyses were performed for each response type (correct, distorted, failed) and each information type (personal *vs.* factual).

Personal Information, Correct Responses (Figure 1a)

An ANOVA of the correct recall responses for personal information revealed an effect of Group [F (2, 39) = 23.07, MSE = .0235, p < .0005, η^2 = .54] but not of Time [F (1, 39) = 1.20, MSE = .0212, p = .281, η^2 = .03]. There was no Time × Group interaction [F (2, 39) < 1, η^2 = .01]. To

understand the effect of Group, the groups were examined in pairs. These analyses showed that, not surprisingly, patients with AD correctly recalled less personal information than those with MCI [$F(1, 25) = 30.70$, $MSE = .0230$, $p < .0005$, $\eta^2 = .55$] and older adult controls [$F(1, 24) = 36.15$, $MSE = .0271$, $p < .0005$, $\eta^2 = .60$]. Patients with MCI and older adult controls correctly recalled personal information to a similar extent [$F(1, 29) = 1.50$, $MSE = .0209$, $p = .230$, $\eta^2 = .05$].

Personal Information, Distorted Responses (Figure 1b)

An ANOVA of the distorted recall responses for personal information revealed an effect of Group [$F(2, 39) = 6.58$, $MSE = .0236$, $p = .003$, $\eta^2 = .25$] but not of Time [$F(1, 39) < 1$, $\eta^2 = .01$], and there was no interaction [$F(2, 39) = 1.27$, $MSE = .0137$, $p = .293$, $\eta^2 = .06$]. The effect of group was present because patients with AD recalled more distorted personal information than those with MCI [$F(1, 25) = 8.54$, $MSE = .0257$, $p = .007$, $\eta^2 = .26$] and older adult controls [$F(1, 24) = 9.07$, $MSE = .0296$, $p = .006$, $\eta^2 = .27$]. Patients with MCI and older adult controls recalled distorted personal information to a similar extent [$F(1, 29) < 1$, $\eta^2 = .01$].

Personal Information, Failed Responses (Figure 1c)

An ANOVA of the failed recall responses for personal information revealed effects of Group [$F(2, 39) = 6.37$, $MSE = .0172$, $p = .004$, $\eta^2 = .25$], Time [$F(1, 39) = 4.37$, $MSE = .0137$, $p = .043$, $\eta^2 = .10$], and a trend toward the Time × Group interaction [$F(2, 39) = 2.71$, $MSE = .0137$, $p = .079$, $\eta^2 = .12$]. The effect of Time was present because overall participants were more likely to respond "I don't know" or the equivalent at 1 year *versus* 3 months. The effect of Group was present because patients with AD were more likely to respond "I don't know" or the equivalent than both those with MCI [$F(1, 25) = 5.37$, $MSE = .0254$, $p = .029$, $\eta^2 = .18$] and older adult controls [$F(1, 24) = 10.06$, $MSE = .0200$, $p = .004$, $\eta^2 = .30$], whereas the latter two groups showed similar levels of failed recall responses [$F(1, 29) = 1.13$, $MSE = .0077$, $p = .298$, $\eta^2 = .04$]. The trend toward an interaction is likely present because the patients with AD showed a greater numerical increase from 3 months to 1 year in their failed recall responses for personal information (.08 to .22) than patients with MCI (.05 to .05) or older adult controls (.02 to .04), although none of the t-tests reached significance [AD: $t(10) = 1.88$, $SEM = .0760$, $p = .090$; MCI: $t(15) < 1$; older controls: $t = 1.07$, $SEM = .0193$, $p = .303$].

Factual Information, Correct Responses (Figure 1d)

An ANOVA of the correct recall responses for factual information revealed effects of Group [$F(2, 39) = 28.71$, $MSE = .0685$, $p < .0005$, $\eta^2 = .60$] and Time [$F(1, 39) = 32.90$, $MSE = .0152$, $p < .0005$, $\eta^2 = .46$]. The effect of Time is present because participants recall of correct factual information declined from 3 months to 1 year. There was no Time × Group interaction [$F(2, 39) = 1.10$, $MSE = .0152$, $p = .342$, $\eta^2 = .05$]. The effect of Group is present because patients with AD made fewer correct responses than both those with MCI [$F(1, 25) = 26.35$, $MSE = .0822$, $p < .0005$, $\eta^2 = .51$] and older adult controls [$F(1, 24) = 94.16$, $MSE = .0399$, $p < .0005$, $\eta^2 = .80$]. There was a trend for patients with MCI to have made fewer correct responses than older adult controls [$F(1, 29) = 3.60$, $MSE = .0803$, $p = .068$, $\eta^2 = .11$].

Factual Information, Distorted Responses (Figure 1e)

An ANOVA of the distorted recall responses for factual information revealed a marginally significant effect of Group [$F(2, 39) = 3.06$, $MSE = .0282$, $p = .058$, $\eta^2 = .14$], no effect of Time [$F(1, 39) < 1$, $\eta^2 = .01$], and no interaction [$F(2, 39) < 1$, $\eta^2 = .04$]. The marginally significant effect of Group is present because patients with AD recalled more distorted factual information than older adults [$F(1, 24) = 4.90$, $MSE = .0332$, $p = .037$, $\eta^2 = .17$] but not patients with MCI [$F(1, 25) = 2.97$, $MSE = .0338$, $p = .097$, $\eta^2 = .10$]. Patients with MCI and older adult controls recalled a similar amount of distorted factual information [$F(1, 29) < 1$, $\eta^2 = .02$].

Factual Information, Failed Responses (Figure 1f)

An ANOVA of the failed recall responses for factual information revealed effects of Group [$F(2, 39) = 21.50$, $MSE = .0590$, $p < .0005$, $\eta^2 = .52$] and Time [$F(1, 39) = 7.65$, $MSE = .0348$, $p = .009$, $\eta^2 = .16$]. There was no interaction [$F(2, 39) < 1$, $\eta^2 = .05$]. The effect of Time is present because overall participants were more likely to respond "I don't know" or the equivalent at 1 year *versus* 3 months. The effect of Group is present because patients with AD were more likely to respond "I don't know" or the equivalent than both those with MCI [$F(1, 25) = 19.26$, $MSE = .0838$, $p < .0005$, $\eta^2 = .44$] and older adult controls [$F(1, 24) = 49.89$, $MSE = .0464$, $p < .0005$, $\eta^2 = .68$], whereas the latter two groups showed similar levels of failed recall responses [$F(1, 29) = 1.83$, $MSE = .0048$, $p = .186$, $\eta^2 = .06$].

3-Month vs. 1-Year Recognition Responses

Overall Analysis

An ANOVA of the recognition data with Group (AD, MCI, older adults) as a between-subjects variable and Time (3 months *vs.* 1 year), Information Type (personal *vs.* factual), and Response Type (correct, distorted, failed) as within-

subjects variables revealed effects of Information Type [$F(1, 52) = 96.60$, $MSE = .0020$, $p < .0005$, $\eta^2 = .65$] and Response Type [$F(2, 104) = 179.70$, $MSE = .0501$, $p < .0005$, $\eta^2 = .78$]. There were interactions of Information Type × Group [$F(1, 52) = 4.75$, $MSE = .0020$, $p = .013$, $\eta^2 = .15$], Response Type × Group [$F(4, 104) = 44.61$, $MSE = .0501$, $p < .0005$, $\eta^2 = .63$], Time × Response Type [$F(2, 104) = 12.74$, $MSE = .0204$, $p < .0005$, $\eta^2 = .08$], Information Type × Response Type [$F(2, 104) = 66.00$, $MSE = .0281$, $p < .0005$, $\eta^2 = .56$], Information Type × Response Type × Group [$F(4, 104) = 9.93$, $MSE = .0281$, $p < .0005$, $\eta^2 = .28$], and Time × Information Type × Group [$F(2, 104) = 11.74$, $MSE = .0118$, $p < .0005$, $\eta^2 = .18$].

There was no overall effect of Time [$F(1, 52) < .1$, $\eta^2 < .01$], and there were no interactions of Time × Group [$F(2, 52) = 1.99$, $MSE = .0013$, $p = .147$, $\eta^2 = .07$], Time × Information Type [$F(1, 52) < 1$, $\eta^2 = .01$], Time × Information Type × Group [$F(2, 52) = 2.20$, $p = .121$, $\eta^2 = .08$], or Time × Information Type × Response Type × Group [$F(4, 104) < 1$, $\eta^2 = .02$].

The effect of Information Type was present because overall participants made more initial responses to personal than factual questions. The effect of Response Type indicated that overall participants made differing numbers of correct, distorted, and failed responses. The Information Type × Group interaction indicates that the groups differed in their overall numbers of responses to personal and factual information. The Response Type × Group interaction indicated that the groups made different numbers of responses to the different response types. The Time × Response Type interaction indicates that the proportion of correct, distorted, and failed responses changed over time. The Information Type × Response Type interaction indicates that the proportion of correct, distorted, and failed responses were different for the personal *versus* the factual information. The Time × Information Type × Group interaction indicates that the change over time in personal and factual information differed between the groups. The Information Type × Response Type v Group interaction indicates that the proportion of correct, distorted, and failed responses were different for the personal *versus* the factual information among the different groups. As with the recall responses above, to understand the three-way interactions between Time × Information Type × Group and Information Type × Response Type × Group separate analyses were performed for each response type (correct, distorted, failed) and each information type (personal *vs.* factual).

Personal Information, Correct Responses (Figure 2a)

An ANOVA of the correct recognition responses for personal information revealed an effect of Group [$F(2, 52) = 35.85$, $MSE = .0217$, $p < .0005$, $\eta^2 = .58$] but not of Time [$F(1, 52) < .1$, $\eta^2 < .01$]. There was no Time × Group interaction [$F(2, 52) < 1$, $\eta^2 < .01$]. To understand the effect of Group, the groups were examined in pairs. These analyses showed that, not surprisingly, patients with AD recognized less correct personal information than those with MCI [$F(1, 31) = 30.50$, $MSE = .0268$, $p < .0005$, $\eta^2 = .50$], who in turn recognized less correct personal information than older adult controls [$F(1, 39) = 5.18$, $MSE = .0202$, $p = .028$, $\eta^2 = .12$].

Personal Information, Distorted Responses (Figure 2b)

An ANOVA of the distorted recognition responses for personal information revealed an effect of Group [$F(2, 52) = 15.78$, $MSE = .0199$, $p < .0005$, $\eta^2 = .38$] but not of Time [$F(1, 52) = 2.50$, $MSE = .0117$, $\eta^2 = .05$]. There was a trend toward an interaction [$F(2, 52) = 2.79$, $MSE = .0117$, $p = .071$, $\eta^2 = .10$]. The effect of group was present because patients with AD recognized more distorted personal information than those with MCI [$F(1, 31) = 11.34$, $MSE = .0252$, $p = .002$, $\eta^2 = .27$] and older adult controls [$F(1, 34) = 35.85$, $MSE = .0173$, $p < .0005$, $\eta^2 = .51$]. Patients with MCI showed a near significant trend to recognize distorted personal information more than older adult controls [$F(1, 39) = 3.72$, $MSE = .0178$, $p = .061$, $\eta^2 = .09$]. The trend toward an interaction is present because patients with AD recognized less distorted personal information over time [$t(13) = 2.79$, $SEM = .0374$, $p = .015$], while patients with MCI and older adult controls showed no change [$F(1, 39) < 1$, $\eta^2 < .01$].

Personal Information, Failed Responses (Figure 2c)

An ANOVA of the failed recognition responses for personal information revealed effects of Group [$F(2, 52) = 9.91$, $MSE = .0116$, $p < .0005$, $\eta^2 = .28$], and Time [$F(1, 52) = 6.25$, $MSE = .0068$, $p = .016$, $\eta^2 = .11$], but no Time × Group interaction [$F(2, 52) = 1.78$, $MSE = .0068$, $p = .178$, $\eta^2 = .06$]. The effect of Time was present because overall participants were more likely to endorse "I don't know" at 1 year *versus* 3 months. The effect of Group was present because patients with AD were more likely to endorse "I don't know" than both those with MCI [$F(1, 31) = 7.19$, $MSE = .0189$, $p = .012$, $\eta^2 = .19$] and older adult controls [$F(1, 34) = 13.99$, $MSE = .0155$, $p = .001$, $\eta^2 = .29$]. Patients with MCI showed a near significant trend toward more failed recognition responses compared with the older adult controls [$F(1, 39) = 3.62$, $MSE = .0024$, $p = .065$, $\eta^2 = .09$].

Factual Information, Correct Responses (Figure 2d)

An ANOVA of the correct recognition responses for factual information revealed effects of Group [F

(2, 52) = 51.07, MSE = .0501, $p < .0005$, $\eta^2 = .66$] and Time [F (1, 52) = 34.68, MSE = .0116, $p < .0005$, $\eta^2 = .40$]. The effect of Time is present because participants recognition of correct factual information declined from 3 months to 1 year. There was no Time × Group interaction [F (2, 52) < .1, $\eta^2 < .01$]. The effect of Group is present because patients with AD recognized fewer correct answers than those with MCI [F (1, 31) = 29.40, MSE = .0720, $p < .0005$, $\eta^2 = .49$] who in turn recognized fewer correct answers than older adult controls [F (1, 39) = 11.43, MSE = .0599, p = .002, $\eta^2 = .23$].

Factual Information, Distorted Responses (Figure 2e)

An ANOVA of the distorted recognition responses for factual information revealed an effect of Group [F (2, 52) = 6.77, MSE = .0184, p = .002, $\eta^2 = .21$], no effect of Time [F (1, 52) < .1, $\eta^2 < .01$], and no interaction [F (2, 52) = 1.36, MSE = .0092, p = .266, $\eta^2 = .05$]. The effect of Group is present because patients with AD recognized more distorted factual information than older adult controls [F (1, 34) = 14.24, MSE = .0170, p = .001, $\eta^2 = .30$] but not patients with MCI [F (1, 31) = 2.24, MSE = .0212, p = .145, $\eta^2 = .07$]. Patients with MCI also recognized more distorted factual information than older adult controls [F (1, 39) = 4.84, MSE = .0175, p = .034, $\eta^2 = .11$].

Factual Information, Failed Responses (Figure 2f)

An ANOVA of the failed recognition responses for factual information revealed effects of Group [F (2, 52) = 29.67, MSE = .0391, $p < .0005$, $\eta^2 = .53$] and Time [F (1, 52) = 25.98, MSE = .0125, $p < .0005$, $\eta^2 = .33$] and a Time × Group interaction [F (2, 52) = 4.03, MSE = .0125, p = .024, $\eta^2 = .13$]. The effect of Time is present because overall participants were more likely to endorse "I don't know" at 1 year *versus* 3 months. The effect of Group is present because patients with AD were more likely to endorse "I don't know" than those with MCI [F (1, 31) = 22.22, MSE = .0603, $p < .0005$, $\eta^2 = .42$], who were in turn marginally more likely to endorse "I don't know" than older adult controls [F (1, 39) = 4.05, MSE = .0248, p = .051, $\eta^2 = .09$]. The interaction is likely present because the magnitude of the increase in failed recognition responses over time increased more dramatically for the patients with AD (.35 to .55) than for patients with MCI (.13 to .21) or for older adult controls (.07 to .12).

Discussion

We used the September 11, 2001 terrorist attacks as an opportunity to examine the decline of episodic memory in patients with AD and patients with MCI for emotional and consequential events outside of the laboratory over a period of months. The results of our study demonstrated some similarities among the three groups. Across all participants, recall and recognition of personal and factual information declined from the initial to the three-month time point. Additionally, across all participants from the three-month to the one-year time point, recall and recognition of personal information was relatively stable, whereas recall and recognition of factual information declined. And for the three-month to one-year time point, the slope of the decline for recall and recognition of factual information, and the stability of recall and recognition of personal information was similar between the three groups. Differences, however, were also observed. Compared to healthy older adults, patients with AD and MCI showed less recall and recognition of personal and factual information at the initial time point, and a more rapid decline of recognition of personal and factual information from the initial to the three-month time point. In brief, compared to older adults, patients with AD and MCI (1) showed lower levels of recall and recognition of personal and factual information at the initial time point, (2) showed a greater decline in their recognition of personal and factual information from the initial to the three-month time point, (3) showed a similar stability of their personal information from the three-month to the one-year time point, and (4) showed a similar decline in their recall and recognition of factual information from the three-month to the one-year time point. We believe that there are important implications of these results for understanding the neuropsychology of patients with AD and MCI, and for aiding memory of these patients in the clinic.

The fact that patients with AD and MCI showed lower levels of recall and recognition of personal and factual information at the initial time point compared to older adults, support the idea that these patients show impaired encoding. That from the three-month to the one-year time point all groups showed a similar decline of factual information and a similar stability of personal information could suggest that the impairment of initial encoding may be the primary memory impairment in patients with AD, consistent with several previous studies (Kopelman, 1985; Degenszajn et al., 2001; Greene et al., 1996; White and Ruske, 2002). However, the more rapid decline of memory in patients with AD and MCI compared with older adults from the initial to the three-month time point for recognition of personal and factual information suggests that patients with AD and MCI do suffer from a rapid rate of forgetting (consistent with McBride et al., 2002; Vanderploe et al., 2001) in addition to faulty initial encoding. Our results are therefore most consistent with several studies which found both impairment in the initial encoding of information and a more rapid

rate of forgetting (Christensen et al., 1998; Grober and Kawas, 1997; Moulin et al., 2004).

One possible explanation suggested by these results as shown in Figures 1 and 2 is that patients with AD and MCI show impaired encoding of information and a more rapid rate of forgetting until the information has been consolidated; once the information has been consolidated, its decay rate becomes the same as that of healthy older adults. This explanation involves a number of assumptions: that encoding can be measured by the initial time point although it was 1 to 3 weeks after the event, and that consolidation has occurred sufficiently by three to four months after the event. This explanation has the appeal, however, that it appears consistent with most clinicians' views of episodic memory in AD; namely that patients with AD show difficulties learning new information, that the new information which is learned shows a rapid rate of forgetting, but older, consolidated memories are relatively preserved.

Our findings are helpful for our understanding of memory in patients with AD. We found that for emotional and consequential real-life events, personal information was better remembered than factual information, and although their memories were significantly impaired compared to healthy older adults, personal memories were still accurate one year later 38% and 43% of the time for recall and recognition, respectively (Table II). This finding is consistent with the commonly observed clinical finding that patients with early AD can still remember information and events if they are sufficiently salient as to engender adequate encoding. Amygdala activation, which is present when emotional information is encoded (Kensinger and Schacter, 2006), may help engender adequate encoding, and may help explain why traumatic events such as the September 11, 2001 terrorist attacks are remembered by the patients. Furthermore, it may be the greater contribution of the amygdala-based emotional network to personal *versus* factual information that explains why patients with AD demonstrated fairly high levels of memory for personal relative to factual information at the 1-year time point. Consistent with this possibility, in a study of patients with AD who experienced the Kobe earthquake in Japan, Mori et al. (1999) found that the volume of the amygdala (and not hippocampus) correlated with the patients' personal memory for the earthquake, whereas neither hippocampal or amygdala volume correlated with factual memory of the event.

The present study has several clinical implications. Because others and we found that impaired encoding is one of the primary problems of memory in patients with AD, it follows that novel medications designed to aid encoding should improve the memory of these patients. White and Ruske (2002) showed, in fact, that the cholinergic drugs do affect encoding and not the rate of forgetting. There are many different methods available to enhance encoding, in addition to pharmacologic therapy. We have previously shown that both repetition (Budson et al., 2000; Gallo et al., 2004) and pairing items with pictures (Budson et al., 2002) enhances encoding; these and other methods can be used to help the patient with AD when there is important information to be remembered.

In addition to examining accurate memories, our study examined memory distortions of personal and factual information. Memory distortions were common, and, interestingly, there was no change in the level of distortions across the participant groups from 3 months to 1 year (with the exception of the patients with AD who showed a decline in their memory distortions in the recognition analyses for personal information). Patients with AD showed more distortions of memory of both personal and factual information compared to older adult controls in both the recall and recognition analyses. Compared to older adult controls, patients with MCI showed a similar number of memory distortions in the recall analyses, but showed either a significantly greater or a near significant trend toward greater memory distortions in the recognition analyses for factual and personal information, respectively.

The finding that patients with AD showed more memory distortions than older adult controls in their memories of person and factual information related to the September 11, 2001 terrorist attacks is consistent with a number of studies that have examined memory for other types of events both in the laboratory (Balota et al., 1999; Budson et al., 2000) and outside of it (Forstl et al., 1994; Borson and Raskind, 1997). The importance of understanding memory distortions in patients with AD can be highlighted by the fact that for the patients with AD, across information types and time points memory distortions were as common as correct responses for both recall [$F(1, 10) < 1$] and recognition [$F(1, 13) < 1$]. The results of the present study also add to this literature by demonstrating that despite declining memory accuracy over time, memory distortions remain stable (or even decline, in the case of the recognition analyses for personal information). It is response failures of the patients with AD (responding 'I don't know' or the equivalent) that show an increase over time in all analyses, mirroring much of the results of the patients with MCI and the older adult controls.

There are a number of limitations of the current study, several of which could be improved in future studies, in addition to those mentioned previously in Budson et al. (2004). First, larger sample sizes at the initial time point would allow for greater power to detect differences at the one-year time point, given the high attrition rate of the patients with AD. The number of subjects who participated in this study raises the issue that some interactions from the three-month to the one-year time point may not

have been detected because of a lack of power. Although this is certainly a possibility, we do not believe that it influenced the present results. Interactions were observed from the initial to the three-month time point, and all effect sizes were reported to assure that non-significant but sizeable effects would not be ignored. Second, interviewing the participants at more frequent intervals would help to assure that floor effects were not present in the patients with AD. Figure 1d shows that correct factual recall responses at one year were close to floor. Although this floor effect could cast doubt upon the validity of some of our conclusions, we feel confident that all of our conclusions are valid given the similarity of the correct factual recall results to the correct factual recognition results, and the correct factual recall and recognition results of the patients with MCI (who were certainly not at floor). Floor effects were also not an issue in the personal information analyses. Third, patients with MCI are heterogeneous in etiology; studies suggest that only about 70% of such patients eventually convert to AD (Petersen et al., 2001). Follow-up is necessary to know which patients truly had incipient AD.

One limitation deserves special mention. Healthy older adults reported that they both followed the media coverage more closely and talked more about the attacks than did patients AD (and to some extent patients with MCI). We cannot, therefore, definitively conclude that the differences observed between the groups are solely attributable to memory differences, and not to differences in the review and re-encoding of information. Although undesirable from a theoretical standpoint, the differences observed in this study may be generalizable to other memories outside of the laboratory. The extent to which patients with AD review information less than healthy older adults may be attributable to a number of factors, including a diminished social network, reduced access to certain types of media (e.g., the internet), in addition to changes in cognition and memory. An examination of such differences may be an important area of future research in our understanding of memory in patients with AD outside of the laboratory.

In summary, we used the September 11, 2001 terrorist attacks as an opportunity to examine the decline of episodic memory in patients with AD, patients with MCI, and older adult controls outside of the laboratory over a period of months. We found that compared to healthy older adults, patients with AD and MCI showed impaired memory at the initial time point, more rapid forgetting from the initial to the three-month time point, and very similar changes in memory from the three-month to the one-year time point. We speculated that these findings were consistent with patients with AD and MCI showing initial impaired encoding and a more rapid rate of forgetting compared with healthy older adults, but that once the memories had been consolidated, their decay rate became similar to that of healthy older adults. Although memory distortions were common among all groups, they were greatest in the patients with AD. Interestingly, across all groups memory distortions did not increase from 3 months to 1 year, but response failures did. In conclusion, studies that examine memory outside of the laboratory necessarily come with a number of limitations, but these studies have the potential to provide new information about memorial processes in AD that would not otherwise be obtainable.

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