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Learning Facts From Fiction: Effects of Healthy Aging and Early-Stage Dementia of the Alzheimer Type

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Healthy younger and older adults and individuals with very mild or mild dementia of the Alzheimer type (DAT) listened to and read fictional stories containing correct and incorrect facts about the world. Of interest was their use of this story information to answer questions on a later test of general world knowledge. Prior exposure to relatively well-known facts boosted all subjects' ability to correctly answer general knowledge questions. Reading incorrect facts in the stories led to misinformation effects in healthy older adults (although these effects were smaller than those observed in younger adults). DAT individuals showed reduced effects of story exposure; effects were greatest in a situation that reminded DAT individuals that the stories might provide the answers to the questions. Benefits of story reading depended on activation of the semantic network, whereas costs of story reading were more dependent on episodic memory processes.

Fictional stories often contain references to the real world; that is, the stories of movies and novels often take place in familiar places, time periods, and political settings. As such, fictional accounts are a source of information about the world. Reading fact-filled stories affects younger adults' ability to answer general world knowledge questions (Marsh, Meade, & Roediger, 2003). After reading stories containing correct information about the world, younger adults correctly answered more questions on a later test of general world knowledge than if they had not read the relevant stories. However, by definition, fiction is not always accurate. Accordingly, reading misinformation in stories also has several negative consequences. Marsh et al. (2003) found that younger adults later used the misinformation to answer general world knowledge questions to such an extent that sometimes their ability to correctly answer questions was reduced below a neutral baseline. In addition, younger adults often claimed to have "known" misinformation answers prior to the experimental session, even though baseline production of misinformation was rare (indicating it was unlikely to have been known prior to the experiment). Of interest in the current research program was the effect of reading similar stories on healthy older adults and individuals with dementia of the Alzheimer type (DAT). First we discuss why we are interested in the performance of healthy older adults, and then we turn to DAT individuals.

Memory in Healthy Older Adults

In numerous paradigms, older adults are more vulnerable to false memories than are younger adults. We list just a few of them here. For example, compared with younger adults, older adults were more likely to falsely remember a nonpresented associate following presentation of a list of related words (Balota, Cortese, et al., 1999; Kensinger & Schacter, 1999; Norman & Schacter, 1997). After viewing photographs, older adults were more likely to falsely "remember" having seen the depicted acts in a prior video (Schacter, Koutstaal, Johnson, Gross, & Angell, 1997). They were also more likely to mistakenly interpret prior study of a name as fame (Dywan & Jacoby, 1990) and were less able to disregard a misleading prime flashed briefly prior to the memory test item (Jacoby, 1999).

Older adults have also shown robust suggestibility in eyewitness misinformation studies (e.g., Multhaup, De Leonardis, & Johnson, 1999), in which subjects are exposed to an original event in the laboratory (e.g., a slide show) and then misled about that event. When tested later on the original event, subjects produce or choose the misinformation at higher rates than baseline. Our review of the literature yielded three studies in which older adults were more suggestible than younger adults (Cohen & Faulkner, 1989; Loftus, Levidow, & Duensing, 1992; Mitchell, Johnson, & Mather, 2002). A fourth study found no age differences in suggestibility (Coxon & Valentine, 1997), and a fifth found younger adults to be more suggestible in some circumstances (Marche, Jordan, & Owre, 2002).

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Suggestibility in the eyewitness and other paradigms does not necessarily imply suggestibility in the fiction paradigm. There are several prerequisites for suggestibility. One needs to remember the misinformation, and in prior experiments, older adults have recognized fewer suggested items than have younger adults (e.g., Mitchell et al., 2002). If older adults do not encode and later retrieve the misinformation, then a misinformation effect should not be expected. Assuming the misinformation is retrieved, it still needs to be accepted as the correct answer. Older adults may be less suggestible when the misinformation contradicts preexperimental world knowledge than when it contradicts an experimental event such as a movie. That is, although older adults may be impaired on an episodic memory test such as recalling the details of a movie (e.g., Marche et al., 2002), they are not impaired in general world knowledge. Older adults' confidence in general knowledge is as high as younger adults' confidence (Marquié & Huet, 2000), and older adults are less susceptible to pressure to conform (Pasupathi, 1999), potentially making them less suggestible within the general knowledge domain.

Thus, our experiments focused on whether older adults can be misled on general world knowledge. In Experiment 1, we established older adults' suggestibility in our paradigm, and in Experiment 2, we compared the size of this effect to that observed in younger adults.

Memory in DAT Individuals

In contrast to the numerous studies on false memories in healthy older adults, few studies have examined false memories in DAT individuals. Some researchers have investigated intrusions in the context of other memory tasks (e.g., Fuld, Katzman, Davies, & Terry, 1982), and there has been some interest in the clinical implications of memory error. In general, though, few researchers have placed DAT individuals in the laboratory paradigms typically used to create and study false memories.

DAT individuals do appear to be susceptible to memory illusions that depend on the activation of preexisting semantic associations. That is, although it is known that DAT individuals have problems with a number of semantic memory tasks (e.g., Hodges & Patterson, 1995; Salmon, Butters, & Chan, 1999), they still show false memories thought to arise from coactivation of simple concepts. DAT patients have been suggestible in the Deese–Roediger–McDermott (DRM) paradigm, in which subjects typically study lists of related words (*thread, pin, eye,* etc.) and later falsely recall nonpresented items (e.g., *needle;* Roediger & McDermott, 1995). In a study with multiple age groups and multiple levels of dementia severity, Balota, Cortese, et al. (1999) found that false recall was constant across groups, even though veridical recall declined dramatically as a function of age and dementia severity (see also Watson, Balota, & Sergent-Marshall, 2001). One explanation for this seeming paradox is that the illusion occurs via activation of the related "needle" concepts and that these associations are still available in individuals with early-stage DAT. This is not to say that DAT individuals perform at normal levels on all semantic memory tasks (see Nebes, 1989, for a review) or that their semantic networks are completely normal (Chan et al., 1995). However, a number of studies have shown preserved semantic priming in individuals with early-stage DAT, suggesting that at least some semantic associations are relatively intact even if they are not accessible via explicit retrieval (e.g., Balota & Duchek, 1991; Balota, Watson, Duchek, & Ferraro, 1999; Nebes, Martin, & Horn, 1984). Supporting the role of semantic activation in the DRM illusion, in other studies DAT individuals were unable to take advantage of episodic information that normally helps people to reduce the illusion. They did not benefit from repeated study trials (which instead served only to boost activation; Budson, Daffner, Desikan, & Schacter, 2000) or from more distinctive picture presentation of associates (Budson, Sitarski, Daffner, & Schacter, 2002).

In the present study, we were interested in whether DAT individuals would show any effects of prior story reading. That is, would listening to a story filled with correct and incorrect facts about the world affect their performance on a later test of general world knowledge? To the extent that semantic associations are relatively spared in early-stage DAT (see Hutchison & Balota, 2003), story reading may increase correct answers on a later test because of activation of preexisting knowledge during reading.

What was less clear was whether story exposure would lead to use of story errors on a later general knowledge test. This would require learning new facts, and both healthy older adults and DAT individuals have deficits in learning new associations (e.g., Duchek, Cheney, Ferraro, & Storandt, 1991; Faust, Balota, & Spieler, 2001; Granholm & Butters, 1988; Ruch, 1934). This deficit in learning new associations also extends to learning false facts about real people, a type of misinformation similar to that investigated in the current experiments. For example, in a study by Goldman and colleagues (Goldman, Winograd, Goldstein, O'Jile, & Green, 1994), control subjects and DAT individuals learned made-up facts via repeated questioning with false feedback; 30 s later, DAT individuals recalled only 40% of the made-up facts, whereas control subjects recalled 81%, even after a 1-hr delay. The delay in the current study was on average longer than 30 s (as the misinformation was spread throughout a story presented over a 7-min period). In addition, the relation between story and test was less clear, whereas in the Goldman et al. (1994) study, the same target question was simply repeated after a one-question lag.

Thus, of interest was whether story reading would affect the answers of DAT subjects on the final test. Are enough associations intact in DAT subjects to allow for coactivation of question–answer pairs?

Current Research Program

In both experiments, subjects heard and read short stories containing correct and incorrect information about the world and then took a general knowledge test. Half the story facts were high prior knowledge, and half corresponded to lesser known facts, as defined by the Nelson and Narens (1980) norms. This manipulation was included because subjects should be more likely to notice misinformation for easy questions and thus reduce their reliance on the story (e.g., Loftus, 1979). The Appendix provides a sample of story paragraphs, critical facts, and test questions.

Healthy older adults and DAT individuals participated in both experiments; Experiment 2 also included a control group of younger adults. Procedurally, the two experiments were identical except for the testing phase; in Experiment 2, each cued recall

Table 1
Demographics and Psychometric Performance as a Function of Group and Experiment

Variable	Experiment 1		Experiment 2	
	Healthy older adults	DAT adults	Healthy older adults	DAT adults
Demographics				
Age	74.3 (9.1)	76.0 (8.6)	77.9 (8.5)	77.1 (8.2)
No. of men/women	9/18	18/15	15/27	20/20
Education (years)	15.1 (3.4)	14.4 (2.8)	13.4 (3.0)	14.7 (3.0)
Psychometrics[a]				
WMS				
Associate Learning	15.8 (4.1)	10.3 (4.1)	14.7 (3.6)	11.0 (3.8)
Digit Span (Forward)	6.3 (1.1)	6.3 (1.1)	6.3 (1.2)	6.1 (1.4)
Digit Span (Backward)	5.2 (1.2)	4.4 (1.2)	5.2 (1.2)	4.1 (1.3)
Logical Memory	11.2 (3.2)	5.7 (3.8)	9.9 (3.9)	5.4 (3.8)
Mental Control	7.7 (1.8)	6.4 (2.3)	7.5 (1.8)	7.1 (2.1)
WAIS				
Block Design	31.7 (8.8)	21.8 (10.8)	31.6 (9.2)	24.4 (12.2)
Digit Symbol	50.6 (11.9)	33.6 (14.3)	47.1 (11.7)	37.4 (13.3)
Information	22.6 (4.9)	16.1 (5.7)	21.5 (4.0)	16.8 (5.5)
Boston Naming Test	55.7 (5.7)	47.6 (9.4)	55.4 (4.2)	48.7 (10.5)
Category Fluency	21.9 (5.8)	13.5 (6.4)	21.1 (6.1)	15.1 (6.0)
Benton Copy Test	9.8 (0.6)	9.1 (1.3)	9.9 (0.3)	9.3 (1.2)
Trail Making Test—Part B	89.0 (33.4)	122.5 (50.3)	95.8 (44.1)	124.4 (45.4)
Word Fluency	33.0 (11.8)	24.4 (9.3)	29.8 (10.9)	24.6 (9.4)

Note. Standard deviations are in parentheses. DAT = dementia of the Alzheimer type; WMS = Wechsler Memory Scale; WAIS = Wechsler Adult Intelligence Scale.
[a] For the psychometric scores, better performance is reflected as a higher score for all measures except for Trail Making Test—Part B.

question was followed by a two-alternative forced-choice (2AFC) version and a question about whether the chosen answer had appeared in the story.

We predicted that healthy older adults would benefit from previously having read correct answers, and that DAT individuals would also benefit to the extent that the relevant associations were still intact. Our predictions about misinformation were less clear, as this would require successful learning and retrieval of new associations, and sometimes these new associations would contradict preexperimental ones.

Experiment 1

Method

Subjects. Dementia was scored according to the Washington University Clinical Dementia Rating (CDR) Scale; the accuracy and reliability of this scale have been well documented (e.g., Berg et al., 1998). Sixty subjects participated, of whom 27 were classified as healthy older adults (CDR = 0). The remaining 33 subjects were classified as having very mild (n = 26) or mild (n = 7) DAT (CDRs = .5 or 1, respectively).[1] Subjects were recruited from the participant pool of the Alzheimer's Disease Research Center (ADRC) at Washington University. They were screened for depression, severe hypertension, possible reversible dementias, and other disorders that might affect cognition. DAT individuals were included or excluded on the basis of the criteria of the National Institute of Neurological and Communicative Disorders and Stroke—Alzheimer's Disease and Related Disorders Association (McKhann et al., 1984).

Psychometric scores were obtained from the Washington University ADRC. All subjects took the test battery, although not all subjects completed all the tests. Tests included the Associate Learning, Digit Span (Forward and Backward), Logical Memory, and Mental Control subtests of the Wechsler Memory Scale (Wechsler & Stone, 1973); the Benton Visual Retention (Copy) Test (Benton, 1963); the Block Design, Digit Symbol, and Information subtests from the Wechsler Adult Intelligence Scale (Wechsler, 1955); the Boston Naming Test (Goodglass & Kaplan, 1983); the Trail Making Test—Part B (Armitage, 1945); and the Word Fluency Test (Thurstone & Thurstone, 1949). Table 1 shows the demographic and psychometric variables as a function of group. Healthy control subjects and DAT individuals did not differ in age ($t < 1$) or in years of education ($t < 1$). Healthy older adults outperformed DAT subjects on the majority of the psychometric tests. Of the measures listed in Table 1, only one difference failed to reach significance. Healthy older adults and DAT individuals did not differ on Forward Digit Span ($t < 1$).

Design. The experiment had a 2 (ease of test question) × 3 (framing of facts: consistent, neutral, or misleading) × 2 (group) design. Group was the only between-subjects factor. Facts were framed to include the correct answer (consistent), no answer (neutral), or an incorrect answer (misleading). Half of the facts were high prior knowledge; the rest were

[1] In Experiment 1, 7 of the 33 DAT subjects (21%) had CDR scores of 1. In Experiment 2, 9 of the 40 DAT subjects (23%) had CDR scores of 1. The analyses were also conducted without these subjects, so that we included only DAT subjects with CDR scores of .5. The proportions of correct and misinformation answers paralleled those of the entire group of subjects, and the same conclusions were reached. Thus, we chose to include all DAT subjects in this article rather than eliminate data from special-population subjects.

low prior knowledge. The dependent measures were production of correct answers and production of misinformation answers on the general knowledge test.

Materials. Two stories were adapted from Marsh et al. (2003; see also Marsh, in press). One story described a summer job in a planetarium, and the other described a boy's science fair project. Both were clearly fictional, containing characters, dialogue, and plot. Each was double spaced in 14-point font and close to seven pages. Audio versions of each story were recorded; these were approximately 7 min long.

Each story referred to 18 critical facts from the Nelson and Narens (1980) general knowledge norms. A different set of 18 facts was used in each of the two stories. Nine facts in each story were defined as high prior knowledge; on average, 66% of students in Nelson and Narens's study answered these questions correctly. The remaining facts were low prior knowledge; on average, 17% of students in Nelson and Narens's study answered these questions correctly. One third of the fact framings were consistent, one third were neutral, and one third were misleading. A neutral framing referred to the later question without giving the correct answer, a consistent framing gave the correct answer, and a misleading framing suggested a plausible incorrect answer from the same category (e.g., another city). The Appendix includes an example; subjects read "go to the international science fair in Moscow, the capital of Russia" (consistent); "go to the international science fair" (neutral); or "go to the international science fair in St. Petersburg, the capital of Russia" (misleading). On the final test, they answered, "What is the capital of Russia?" Three versions of each story were created to counterbalance fact framing across subjects. Thus, across subjects, there were six different story booklets (and six matching audiotapes).[2]

The general knowledge test consisted of 24 questions, including 18 critical ones. Half the critical questions were easy and half were hard. One third corresponded to facts that had been read in a neutral format, one third to those read in a consistent format, and one third to those read in a misleading format. Six easy filler questions were interspersed. All questions were in a cued recall format. Two different tests were constructed, one for each of the stories.

Finally, we used six versions of a questionnaire that measured how surprised the subject was to receive the correct information. Each version contained six correct statements, one corresponding to each of the six facts on which the subject had been misled. For example, subjects who had been misled as to the capital of Russia rated their surprise in reading "Moscow is the capital of Russia" using a 3-point scale. Of interest was whether subjects believed any misinformation answers; to the extent that this occurred, subjects should be surprised by the corrected versions of the facts.

Procedure. Subjects were tested individually, as part of a longer session that lasted between 90 min and 2 hr (and contained multiple breaks and tasks). In Phase I, story exposure, each subject read one of the two stories while listening to an audiotape of the same story. This procedure was modeled after a "books-on-tape" experience. Subjects were instructed to pay close attention and to tell the experimenter if the volume required adjustment.

In Phase II, the general knowledge test, each subject verbally answered a series of 24 questions; each question required production of the desired answer (cued recall). Subjects were instructed to avoid guessing and to say "I don't know" if they did not know the answer. They were warned that some of the questions would be difficult and that they should not expect to be able to answer them all but should just do the best they could. The experimenter read each question aloud, rephrasing it if necessary. The experimenter noted if the subject was unable to answer the question. Finally, in Phase III, subjects completed the surprise questionnaire. The experimenter read each of the six corrected facts aloud and recorded the subject's judgment of surprise.

Results

All results were significant at the .05 level unless otherwise noted.

Cued recall: Correct. A 2 (group) × 3 (fact framing) × 2 (ease of question) analysis of variance (ANOVA) was computed on the proportion of questions answered correctly. The relevant data are shown in Table 2. For the reader's ease, the table also displays the facilitation and interference rates. Facilitation (consistent minus neutral) represents the boost in subjects' correct answers, over their baseline performance, after they had read consistent answers in the story. Interference (misleading minus neutral) represents the decline in subjects' correct answers, compared with their baseline performance, after they had read misleading answers in the story.

Healthy older adults answered more questions correctly than did DAT individuals, $F(1, 58) = 14.71$, $MSE = 0.25$. As expected, subjects answered more questions correctly when the facts had been framed consistently, $F(2, 116) = 32.24$, $MSE = 0.06$. Also as expected, there was a main effect of question ease, $F(1, 58) = 69.97$, $MSE = 0.07$.

Most critically, the interaction between group and fact framing was significant, $F(2, 116) = 4.89$, $MSE = 0.06$, and this was further qualified by a three-way interaction with question ease that approached signifiance, $F(2, 116) = 3.02$, $MSE = 0.05$, $p < .06$. For healthy older adults, performance following consistent fact framing was significantly higher than the neutral baseline for both easy questions, $t(26) = 2.50$, $SEM = 0.07$, and hard questions, $t(26) = 5.86$, $SEM = 0.06$. Performance following misleading fact framing was marginally lower than the neutral baseline for easy questions, $t(26) = 1.95$, $SEM = 0.07$, $p < .07$, but not hard questions ($t < 1$). A different pattern emerged for DAT individuals. That is, after DAT subjects had read consistently framed facts, a boost above baseline was observed only for easy questions, $t(32) = 2.86$, $SEM = 0.06$, and not for hard ones ($t < 1$). Exposure to misinformation did not drop their performance significantly below the baseline for either easy or hard questions ($ts < 1$).

Cued recall: Intrusion of misinformation. A 2 (group) × 3 (fact framing) × 2 (ease of question) ANOVA was computed on the proportion of questions answered with the target misinformation. The relevant data are shown in Table 3, as are the facilitation and interference rates. Negative facilitation scores (consistent minus neutral) show the benefit of subjects having

[2] Six different versions of the materials were created to counterbalance fact type (consistent, neutral, or misleading) in the two different stories. However, a complete counterbalancing was not completed, and we were faced with the choice of throwing out data from special populations or having an incomplete counterbalance. For correct answers, version never affected the critical Group × Fact-Type interaction. For misinformation answers, version did modulate the fact-type interaction. A series of additional analyses were conducted to ensure that effects involving misinformation were not due to counterbalancing factors. First, similar group differences were obtained when the analyses included only a counterbalanced subset of subjects. That is, DAT subjects produced less misinformation than did healthy older adults, even in a counterbalanced subset. Second, the pattern of results across experiments did not depend on the counterbalancing factor. That is, DAT subjects produced more misinformation in Experiment 2 than in Experiment 1, and this effect did not interact with counterbalance version.

Table 2
Experiment 1: Subjects' Proportion of Correct Answers on the Cued-Recall Test After Reading Facts in Consistent, Neutral, and Misleading Frames and Facilitation (Consistent Minus Neutral) and Interference (Misleading Minus Neutral) Rates

Question difficulty	Consistent	Neutral	Misleading	Facilitation	Interference
Healthy older adults					
Easy	.77	.58	.44	.19	−.14
Hard	.57	.25	.22	.32	−.03
DAT adults					
Easy	.52	.33	.28	.19	−.05
Hard	.19	.15	.13	.04	−.02

Note. DAT = dementia of the Alzheimer type.

read consistent information in the stories, as reflected in a reduction in target misinformation answers. Positive interference scores (misleading minus neutral) indicate that subjects produced more target misinformation after having read these facts in the story.

Overall, baseline production of misinformation was quite low, even among DAT subjects. Misinformation was produced predominately after subjects had read facts framed in a misleading format, $F(2, 116) = 36.19$, $MSE = 0.03$. The misinformation effect was larger for healthy control subjects than for DAT subjects. Statistically, this meant there was a main effect of group, which interacted with fact framing, $F(2, 116) = 12.43$, $MSE = 0.03$. Following exposure to misinformation, healthy control subjects produced misinformation above baseline for both easy questions, $t(26) = 5.05$, $SEM = 0.05$, and hard questions, $t(26) = 4.13$, $SEM = 0.05$. In addition, prior exposure to consistent information buffered healthy older adults from producing misinformation as answers to hard questions, $t(26) = 2.00$, $SEM = 0.04$, $p < .06$. A different pattern emerged for DAT subjects. There was no hint of a misinformation effect for hard questions ($t < 1$). For easy questions, misinformation was produced at higher levels following a misleading framing, but this was only a trend statistically, $t(32) = 1.49$, $SEM = 0.05$, and did not reach traditional levels of significance.

Surprise ratings. We compared the average surprise rating given production of the correct answer to the average surprise rating given production of misinformation, with higher numbers reflecting greater surprise. A 2 (group) × 2 (previous answer) ANOVA was computed on average surprise ratings. This excluded a number of subjects, either because they did not complete the surprise ratings or because they did not have observations in both cells (that is, previously correct and previously misled). However, even with only a subset of subjects included (19 healthy control subjects and 8 DAT subjects), the results were clear. Subjects were more surprised by the corrected facts when they had previously produced the misinformation, $F(1, 25) = 35.61$, $MSE = 0.20$. There was no difference in surprise ratings across groups, nor did group interact with previous answer. When subjects had given the correct answer, they were less surprised ($M = 1.05$ for control subjects, $M = 1.06$ for DAT subjects) than when they had produced the misinformation ($M = 1.74$ for control subjects, $M = 2.00$ for DAT subjects).

Discussion

Healthy older adults showed expected patterns of performance following exposure to a story that contained correct and incorrect facts. After reading consistent information, they answered more questions correctly, regardless of question ease. For both easy and hard questions, prior exposure to misinformation led older adults to produce significant amounts of misinformation on the general knowledge test. In addition, exposure to misinformation reduced their ability to correctly answer easy questions, as compared with the neutral baseline. Thus, although some of the effect of misinformation was via learning of new facts (albeit wrong ones), misinformation also impaired access to previously known facts. Surprise ratings were higher for corrected facts for which subjects had produced the misinformation, suggesting that they had believed the errors.

A very different pattern emerged for DAT individuals. Although they correctly answered more easy questions following exposure to consistent information, they did not show a similar pattern for hard questions. No significant misinformation effects were obtained. There was only a trend toward production of misinformation in response to easy questions; after exposure to misinformation, its production increased 8% above baseline, compared with an increase of 24% for healthy control subjects. DAT individuals did not significantly produce misinformation as answers to hard questions, and reading misinformation did not significantly impair their ability to correctly answer questions.

Thus, DAT subjects showed effects equivalent to those of healthy older adults only for easy questions corresponding to consistently framed facts. The performance of healthy control subjects increased from a baseline of 58% to 77% correct after the subjects had read consistent information, an average change of 19%. DAT individuals' performance increased from a baseline of 33% to 52%, also an average change of 19%. Thus, in this one case, DAT individuals showed as great an effect of story exposure as did healthy older adults.

Table 3
Experiment 1: Subjects' Proportion of Misinformation Answers on the Cued-Recall Test After Reading Facts in Consistent, Neutral, and Misleading Frames and Facilitation (Consistent Minus Neutral) and Interference (Misleading Minus Neutral) Rates

Question difficulty	Consistent	Neutral	Misleading	Facilitation	Interference
Healthy older adults					
Easy	.06	.07	.31	−.01	.24
Hard	.01	.09	.30	−.08	.21
DAT adults					
Easy	.05	.09	.17	−.04	.08
Hard	.06	.05	.08	.01	.03

Note. DAT = dementia of the Alzheimer type.

Floor effects cannot explain why DAT subjects did not show effects of story reading in the other conditions. First, in the case of misinformation, the baselines did not differ significantly across groups, and yet only healthy older adults showed significant production of misinformation. It is noteworthy that reading misinformation led healthy older adults to produce it at considerable rates for hard questions (an increase of 21%), for which the baseline (9%) was exactly the same as that for easy questions for DAT subjects (and easy questions led to an increase in producing misinformation of only 8% in those individuals). Thus, low (or different) baselines were not the reason why DAT subjects failed to produce misinformation. Differing baselines also do not explain the effects of having read correct information in the story. That is, DAT subjects answered fewer neutral questions correctly regardless of question ease but showed normal benefits after having read answers to easy but not to hard questions.

Why would DAT individuals benefit from having read answers to easy but not to hard questions? The state of semantic memory in DAT individuals remains highly debated, with some researchers showing evidence for preserved knowledge and others documenting DAT individuals' problems on semantic memory tasks. Easy questions may be more likely to correspond to knowledge that is still accessible by DAT patients, at least compared with the hard questions in our study. That is, the easy questions refer to more familiar concepts, such as oceans, deserts, and the countries Russia and Japan, and the answers to these questions (e.g., the Pacific, the Sahara, Moscow, and the yen, respectively) are likely also more familiar. Contrast this to difficult questions, which refer to less familiar concepts such as steamboats, vaccines, telegraphs, and constellations; the corresponding answers are surely of lower frequency (e.g., Fulton, Jenner, Morse, and Pegasus, respectively). Hard questions and their corresponding answers may be less likely to be preserved in early-stage dementia and thus less able to benefit from activation through study (e.g., see Chan, Butters, & Salmon, 1997; Hodges & Patterson, 1995).

One possibility is that DAT subjects in our study were similarly affected by story exposure but had a harder time retrieving the requisite answers at test. That is, DAT subjects may have had knowledge of a concept but were unable to produce it in response to a direct question. To examine this possibility, at test in Experiment 2 we again required subjects to answer a cued recall question. However, this question was followed by a 2AFC question (e.g., "Is it Moscow or St. Petersburg?"). Normal performance on the 2AFC would suggest that DAT patients encoded the story information similarly and could retrieve it under some circumstances.

Another interesting issue is how aware DAT patients are of any story reliance. In other paradigms, DAT individuals have shown less awareness of source than have healthy older adults (Multhaup & Balota, 1997), who in turn typically have shown worse source memory than have healthy younger adults. In a longer version (Marsh et al., 2003) of the current procedure, researchers found that younger adults were very good at knowing that facts had been read in the stories. In the current Experiment 2, after subjects chose one of the two alternatives, they then stated whether their answer had been in the story. We expected younger adults to be very good at saying yes, they had read the answers in the story. We expected healthy older adults' performance to be lower than that of younger adults but still above chance in source memory. Because of their source deficits, we expected DAT individuals to be particularly impaired on this task.

Finally, Experiment 2 also included a younger adult control group. The misinformation effects in our older adults followed the predicted patterns; however, it was unknown whether the effects were the same size as would be obtained with younger adults. The changes allowed us to compare all three groups on three memory measures: cued recall, 2AFC, and source memory.

Experiment 2

Method

Subjects. Thirty-six younger adults, 42 healthy older adults, and 40 older adults with very mild ($n = 31$) or mild ($n = 9$) DAT participated in Experiment 2. Older adult subjects were recruited from the same pool as in Experiment 1 and were screened in a similar fashion. Younger adults participated for course credit.

Table 1 shows the demographic and psychometric variables for healthy older and DAT subjects. Healthy control subjects and DAT subjects did not differ in age ($t < 1$) or in education level, $t(80) = 1.82$, $SEM = 0.66$.

The Washington University ADRC provided psychometric scores for all but 1 older subject (1 DAT subject did not complete the battery). All of the remaining subjects completed at least some of the tests. Healthy older adults outperformed DAT subjects on the majority of the tests. Of the 13 measures listed in Table 1, only two differences failed to reach significance. As in Experiment 1, healthy older adults and DAT individuals did not differ significantly on Forward Digit Span ($t < 1$). The two groups were also equivalent on the Mental Control score, $t(79) = 1.16$, $SEM = 0.43$.

Materials. The same materials were used as in Experiment 1, with one important exception. The general knowledge test was revised so that each cued recall question was followed by two additional questions: a 2AFC question and a source question. The 2AFC question required the subject to choose between the correct and misinformation answers. On one half of the questions, the misinformation was offered first, and on one half of the questions, the correct answer was presented first. The source question required the participant to respond yes, the fact had been in the story, or no, it had not been. These three questions were always asked in this sequence, regardless of whether subjects were able to answer the first, cued recall question. For example, the question "What is the capital of Russia?" was followed by "What is the capital of Russia, Moscow or St. Petersburg?" Finally, the subject had to indicate whether the chosen answer (either Moscow or St. Petersburg) had occurred in the story.

Procedure. The procedure of Experiment 2 was the same as that of Experiment 1 except for the test phase. At test, the experimenter first asked the cued recall version of the question, then the 2AFC version, and finally the source version. After asking all three versions of the question, the experimenter moved on to the next item.

Results

Cued recall: Correct. A 3 (group) × 3 (fact framing) × 2 (ease of question) ANOVA was computed on the proportion of questions answered correctly. The relevant data are shown in Table 4, along with the facilitation and interference rates.

Younger adults and healthy older adults showed a similar pattern. That is, younger adults answered more questions correctly following exposure to consistent facts, for both easy questions, $t(35) = 5.39$, $SEM = 0.05$, and hard questions, $t(35) = 3.98$, $SEM = 0.07$. Exposure to misinformation dropped performance

Table 4
Experiment 2: Subjects' Proportion of Correct Answers on the Cued-Recall Test After Reading Facts in Consistent, Neutral, and Misleading Frames and Facilitation (Consistent Minus Neutral) and Interference (Misleading Minus Neutral) Rates

Question difficulty	Consistent	Neutral	Misleading	Facilitation	Interference
		Younger adults			
Easy	.84	.58	.32	.26	−.26
Hard	.57	.14	.10	.43	−.04
		Healthy older adults			
Easy	.68	.46	.29	.22	−.17
Hard	.52	.19	.13	.33	−.06
		DAT adults			
Easy	.51	.32	.23	.19	−.09
Hard	.28	.08	.08	.20	.00

Note. DAT = dementia of the Alzheimer type.

below the neutral baseline, but only for easy questions, $t(35) = 3.98$, $SEM = 0.07$. The same pattern occurred for healthy older adults; they answered more questions correctly following exposure to consistent facts, for both easy questions, $t(41) = 4.35$, $SEM = 0.05$, and hard questions, $t(41) = 4.35$, $SEM = 0.05$. Exposure to misinformation dropped performance significantly below the neutral baseline, but only for easy questions, $t(41) = 3.34$, $SEM = 0.05$.

A different pattern emerged for DAT subjects, as reflected in the significant interaction between group and fact framing, $F(4, 230) = 5.05$, $MSE = 0.06$. DAT subjects answered more questions correctly after reading consistent facts for both easy questions, $t(39) = 3.29$, $SEM = 0.06$, and hard questions, $t(41) = 4.41$, $SEM = 0.05$. However, misinformation never caused their performance to drop significantly below the neutral baseline.

All three groups benefited from story exposure, correctly answering more easy and hard questions. For easy questions, this benefit from story reading was equivalent across groups ($F < 1$). For hard questions, the conclusion about age and DAT varied with dependent measure. That is, reading helped younger adults the most ($M = 0.43$), followed by healthy older adults ($M = 0.33$) and then DAT subjects ($M = 0.20$), $F(2, 115) = 4.40$, $MSE = 0.12$. However, age differences for hard questions disappeared when these differences were expressed as proportions of the neutral baseline. Once the different baselines were taken into account, all three groups benefited equally from story reading.

Story exposure negatively affected the performance of younger and healthy older adults, with correct answers decreasing below baseline for easy questions (but not for hard ones, perhaps because of a floor effect). The cost of misinformation was not significantly greater for younger adults (−26%) than for older adults (−17%), $t(76) = 1.12$, $SEM = 0.08$, and this difference was not significant when expressed as the proportion of change from baseline ($t < 1$). In contrast, having read misinformation did not lead to a decrease below baseline for the DAT individuals.

Cued recall: Intrusion of misinformation. A 3 (group) × 3 (fact framing) × 2 (ease of question) ANOVA was computed on the proportion of questions answered with misinformation. Table 5 contains the data as well as the facilitation and interference rates.

In all groups, a significant misinformation effect was observed. That is, after exposure to misinformation, subjects produced misinformation at a higher rate than baseline. Observed effects in healthy older and younger adults replicated those of Experiment 1. The novel findings were of misinformation effects in DAT individuals for both easy questions, $t(39) = 2.76$, $SEM = 0.04$, and hard questions, $t(39) = 4.69$, $SEM = 0.03$.

There was an interaction between group and fact framing, $F(4, 230) = 11.41$, $MSE = 0.04$. This was driven in part by group differences in the consistent condition. That is, in some cases, prior exposure to the correct answer reduced misinformation production even lower than baseline. This benefit of story reading was observed for younger adults for both easy questions, $t(35) = 2.50$, $SEM = 0.03$, and hard questions, $t(35) = 2.05$, $SEM = 0.05$.

The uniformly low base-rate production of misinformation made it possible to compare the size of the misinformation effect across groups. To compare the size of the effect in younger versus older adults, we computed a 2 (group) × 2 (ease of question) ANOVA on the average misinformation effect (the difference following neutral vs. misleading information). The main effect of group approached significance, $F(1, 76) = 3.46$, $MSE = 0.13$, $p < .07$. When healthy older adults and DAT individuals were compared, the only significant effect was a main effect of group, $F(1, 80) = 6.11$, $MSE = 0.10$. Younger adults produced misinformation at a slightly higher rate than did healthy older adults, who produced significantly more misinformation than did those with DAT.

Forced choice. A 3 (group) × 3 (fact framing) × 2 (ease of question) ANOVA was computed on the proportion of questions answered correctly. The relevant data are shown in Table 6, with the facilitation and interference effects also noted. Because the

Table 5
Experiment 2: Subjects' Proportion of Misinformation Answers on the Cued-Recall Test After Reading Facts in Consistent, Neutral, and Misleading Frames and Facilitation (Consistent Minus Neutral) and Interference (Misleading Minus Neutral) Rates

Question difficulty	Consistent	Neutral	Misleading	Facilitation	Interference
		Younger adults			
Easy	.02	.08	.45	−.06	.37
Hard	.04	.13	.49	−.09	.36
		Healthy older adults			
Easy	.06	.06	.33	.00	.27
Hard	.04	.10	.35	−.06	.25
		DAT adults			
Easy	.06	.04	.16	.02	.12
Hard	.03	.03	.18	.00	.15

Note. DAT = dementia of the Alzheimer type.

Table 6
Subjects' Proportion of Correct Answers on the 2AFC Test After Exposure to Consistent, Neutral, and Misleading Information in the Story and Facilitation (Consistent Minus Neutral) and Interference (Misleading Minus Neutral) Rates

Question difficulty	Consistent	Neutral	Misleading	Facilitation	Interference
			Younger adults		
Easy	.96	.88	.53	.08	−.35
Hard	.88	.63	.39	.25	−.24
			Healthy older adults		
Easy	.87	.76	.57	.11	−.19
Hard	.83	.64	.48	.19	−.16
			DAT adults		
Easy	.78	.71	.63	.07	−.08
Hard	.72	.57	.49	.15	−.08

Note. 2AFC = two-alternative forced choice; DAT = dementia of the Alzheimer type.

data were from 2AFC questions, the misinformation effect was 1 minus the proportion of correct answers.[3]

Subjects' performance on 2AFC questions was similar to their performance on cued recall questions. Younger and healthy older adults picked up both easy and hard correct information from the stories and showed costs following misinformation. DAT individuals showed some, albeit smaller, effects of story exposure. That DAT effects were smaller was reflected in the significant interaction between group and fact framing, $F(4, 230) = 5.67$, $MSE = 0.07$.

Prior reading of correct facts increased correct answers above baseline. This held for younger adults for both easy questions, $t(35) = 2.17$, $SEM = 0.04$, and hard questions, $t(35) = 4.17$, $SEM = 0.06$. This was also true for healthy older adults for both easy questions, $t(41) = 2.55$, $SEM = 0.04$, and hard questions, $t(41) = 3.90$, $SEM = 0.05$. For DAT individuals, the difference was significant for hard questions, $t(39) = 2.97$, $SEM = 0.05$, but not for easy questions.

Of interest was when exposure to misinformation decreased subjects' ability to correctly answer the questions below baseline. This occurred for younger adults for both easy questions, $t(35) = 5.31$, $SEM = 0.07$, and hard questions, $t(35) = 3.81$, $SEM = 0.06$. A similar pattern occurred for healthy older adults for both easy questions, $t(41) = 3.28$, $SEM = 0.06$, and hard questions, $t(41) = 1.97$, $SEM = 0.08$, $p < .06$. For DAT individuals, although performance was numerically below the baseline, these differences were not statistically significant.

Thus, subjects in the three groups showed similar benefits from having read correct answers. The cost of having read misinformation was strongest in younger adults, followed by healthy older adults and then DAT subjects.

Source memory. Figure 1 shows story attributions following selection of the correct answer in the 2AFC test. Idealized performance would involve story attributions only in the consistent condition, because only in this condition were the correct answers actually presented in the story. Younger adults' performance was closest to this ideal pattern; they made story attributions for the majority of correct answers following consistent information but not for correct answers following neutral or misleading framings. The performance of healthy older adults was next highest, and that of DAT individuals was the lowest. Statistics confirmed this pattern. For each cell, we computed the proportion of correct answers attributed to the story. We then subtracted the neutral baseline from the proportion of story attributions observed in the consistent condition. This approach eliminated 13 subjects who did not have at least one observation in each of the necessary cells (leaving 37 healthy older adults, 33 DAT individuals, and 35 younger adults). A 2 (ease) × 3 (group) ANOVA was computed on the difference score. There was a main effect of ease; subjects showed more awareness of the story source for answers to hard questions, $F(1, 102) = 5.78$, $MSE = 0.13$. There was a main effect of group, $F(2, 102) = 37.65$, $MSE = 0.15$, and this did not interact with question ease. Younger adults showed greater story awareness than did healthy older adults for both easy questions, $t(74) = 4.10$, $SEM = 0.07$, and hard questions, $t(71) = 4.84$, $SEM = 0.08$. Healthy older adults in turn showed greater story awareness than did DAT individuals. This difference was significant for easy questions, $t(76) = 2.50$, $SEM = 0.09$, and was significant for hard questions via a one-tailed test, $t(71) = 1.78$, $SEM = 0.10$. Even though DAT individuals showed the lowest levels of source memory, their performance was not at chance.

Figure 2 shows the pattern of source attributions following selection of the misinformation answer in the 2AFC test. Idealized performance would involve story attributions only following misleading fact framings, because only in this condition was the misinformation presented in the story. Again, younger adults' performance was closest to this ideal. They predominately made story attributions for misinformation answers following misleading but not neutral or consistent framings. The performance of healthy older adults was next highest, and that of DAT individuals was the lowest. Statistics again confirmed this pattern, although only 73 subjects (24 healthy older adults, 23 DAT individuals, and 26 younger adults) had data in all the cells needed for analysis. For each cell, we computed the proportion of misinformation answers attributed to the story and then subtracted the neutral baseline. A 2 (ease) × 3 (group) ANOVA was computed on this difference score. The only significant effect was group, $F(2, 70) = 5.07$, $MSE = 0.26$, and this did not interact with question ease. Younger adults showed greater story awareness than did healthy older adults for both easy questions, $t(55) = 4.17$, $SEM = 0.09$, and hard questions, $t(60) = 2.27$, $SEM = 0.11$. Healthy older adults in turn showed greater story awareness than did DAT individuals. This difference did not reach significance for

[3] Because the proportion of correct answers and proportion of misinformation answers were normally complements, only the correct responses are reported here. Only when subjects failed to answer all of the 2AFC questions did the proportion of correct and misinformation answers not sum to 1. However, the interested reader can discern the exact misinformation effects from Figure 2 (which shows source attributions for misinformation answers), and correspondingly, the rate of failure to answer can be derived from 1 minus the sum of the correct answers (see Figure 1) and misinformation answers (see Figure 2).

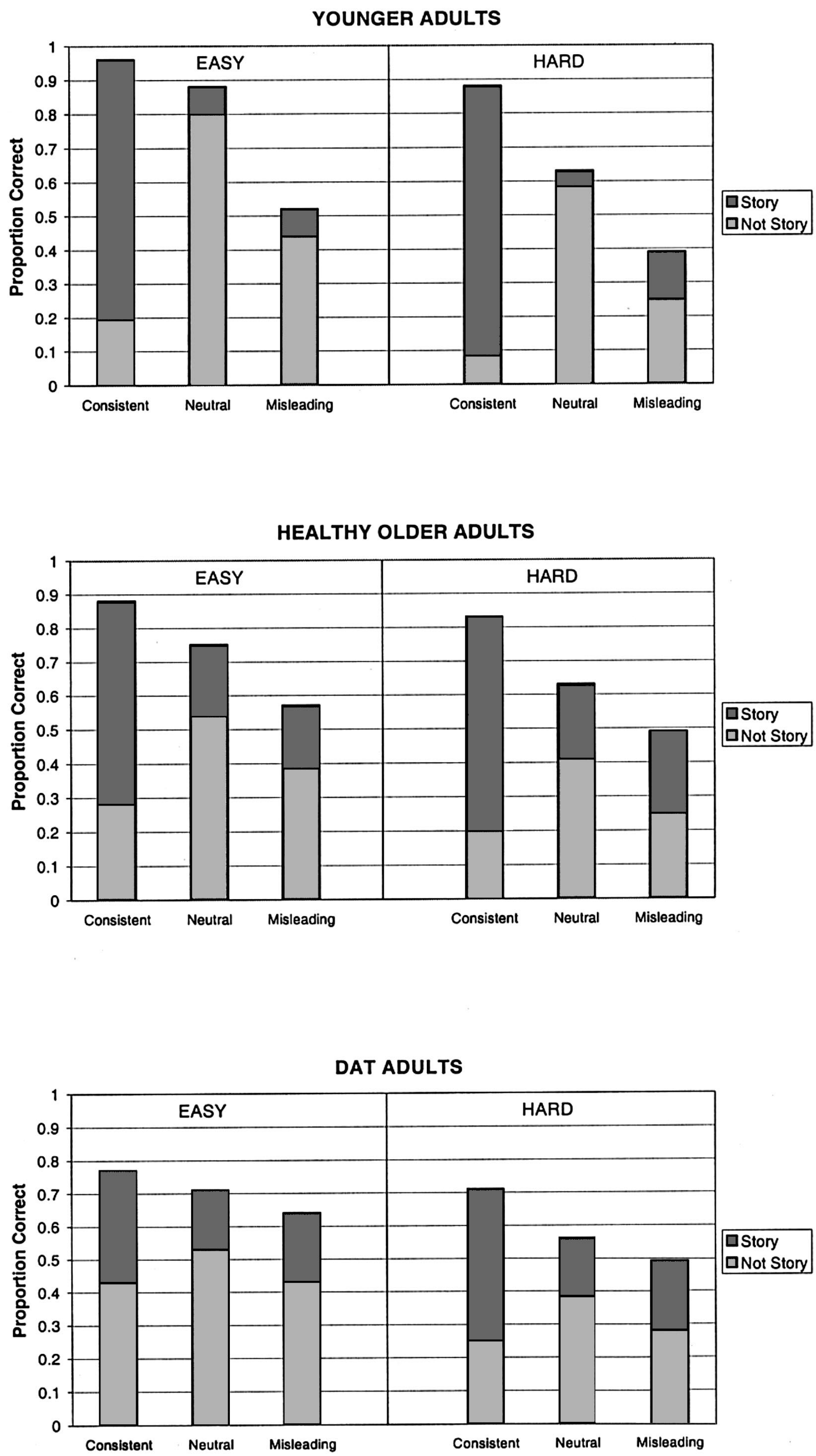

Figure 1. Story and not-story attributions for correctly recognized answers. Easy questions are on the left, and hard questions are on the right. DAT = dementia of the Alzheimer type.

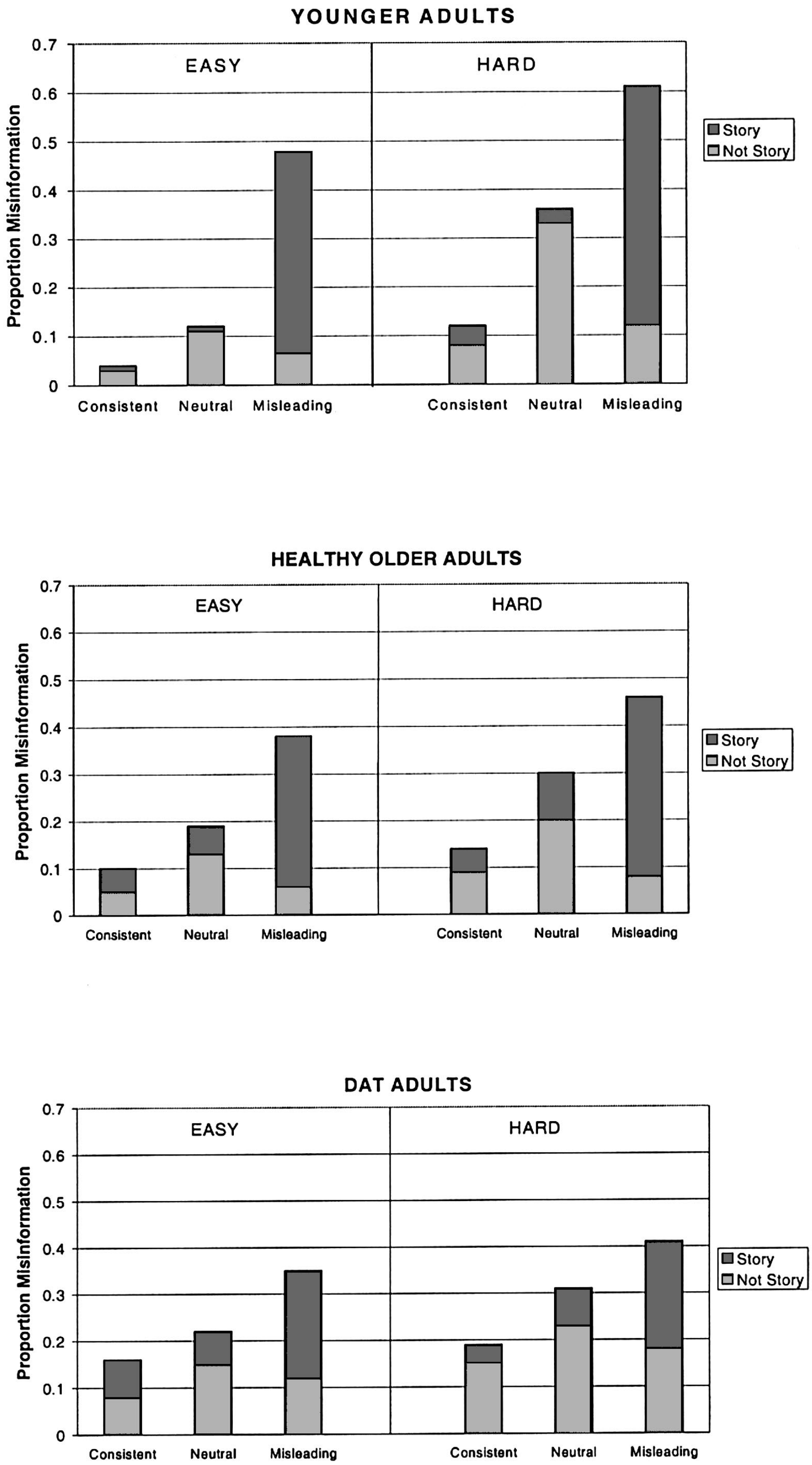

Figure 2. Story and not-story attributions for misinformation answers. Easy questions are on the left, and hard questions are on the right. DAT = dementia of the Alzheimer type.

easy questions but was significant for hard questions via a one-tailed test, $t(58) = 1.68$, $SEM = 0.12$.

Surprise ratings. We examined average surprise ratings as a function of prior answer on the cued recall test (correct vs. misinformation). A 2 (group) × 2 (previous answer) ANOVA was computed on average surprise ratings. A number of subjects were excluded from this analysis because they did not have observations in both cells. As in Experiment 1, subjects were more surprised by the corrected version of facts for which they had previously produced the misinformation, $F(1, 36) = 36.22$, $MSE = 0.19$. There was no effect of group, nor did group interact with prior answer. DAT subjects ($M = 1.00$), healthy older adults ($M = 1.04$), and younger adults ($M = 1.18$) were less surprised when they had answered correctly than when they had produced the misinformation (DAT subjects, $M = 1.67$; healthy older adults, $M = 1.59$; younger adults, $M = 1.47$).

Discussion

In Experiment 2, story reading affected all three groups of subjects. Healthy older adults performed similarly to their counterparts in Experiment 1. However, with the addition of the younger adult group, it was clear that the strongest story effects (especially relating to misinformation) were in younger adults. DAT individuals still showed the smallest effects of story exposure, and this was extended to a 2AFC test that reduced retrieval demands. However, DAT effects were stronger than in Experiment 1 (a finding discussed below). Finally, all three groups of subjects showed some awareness of the story source, although again this was greatest in younger adults, followed by healthy older adults, and lowest in DAT individuals.

In Experiment 2, but not in Experiment 1, story reading helped DAT subjects to correctly answer hard questions. An analysis of DAT subjects compared the size of the benefits of story exposure (production of correct answers after reading consistent facts minus baseline production in the neutral condition) across the two experiments. For hard questions, the benefit from story reading was significantly larger in Experiment 2 than in Experiment 1, $F(1, 61) = 4.32$, $MSE = 0.08$. It did not interact with the counterbalancing factor, nor was it due to differences in the two subject groups on psychometric measures.

Similarly, DAT subjects showed significant production of misinformation in Experiment 2, whereas this was only a trend in Experiment 1, and only for easy questions. Statistics again supported this difference between experiments. An analysis on DAT subjects compared the size of the misinformation effect (production of misinformation after reading misinformation minus baseline production in the neutral condition) across the two experiments. For hard questions, the misinformation effect was significantly larger in Experiment 2 than in Experiment 1, $F(1, 61) = 6.99$, $MSE = 0.11$. Again, this effect did not interact with the counterbalancing factor, nor did it appear to be due to differences in psychometric performance across experiments.

Why would DAT individuals in Experiment 2 show larger effects of story exposure? One possibility is that DAT individuals benefited from the changed procedure of Experiment 2. In Experiment 2, each cued recall question was followed by the 2AFC question and the source question, which would have reminded the DAT subjects of the story context (by asking whether every answer was obtained from the story). If DAT individuals did not naturally think back to the story for a source of answers, then such a reminder might have served to increase their retrieval of answers from the story. It is notable that although DAT subjects showed the lowest awareness of the story source, they were still significantly above chance in attributing answers to the story.

Misinformation effects were largest in younger adults, next largest in healthy older adults, and smallest in DAT individuals. This is in sharp contrast to numerous paradigms showing enhanced suggestibility in older adults (e.g., Dywan & Jacoby, 1990; Jacoby, 1999; Kensinger & Schacter, 1999; Schacter et al., 1997). In addition, DAT individuals were the least suggestible in our paradigm, in contrast to some findings from the DRM paradigm for creating false memories of words (Balota, Cortese, et al., 1999; Watson et al., 2001). In those studies, DAT individuals recalled fewer studied words than did healthy older adults but did not differ in false recall (but see Budson et al., 2000, 2001, 2003, for different results). Thus, we found a different relationship between group and suggestibility in the fiction paradigm than is typical in many false memory paradigms.

There are at least two possible explanations for our results. First, our misinformation involved facts about the world, a domain in which older adults may be particularly resistant to suggestion. Older adults are generally more resistant to conformity pressure than are younger adults (Pasupathi, 1999). Although they scored slightly lower than younger adults on neutral questions, older adults may have known their facts over a longer time period. Second, older adults may have been less suggestible, because they were less likely to encode and later remember the misinformation. Older adults are less likely to recognize that misinformation has been presented in an experiment (Mitchell et al., 2002). Remembering the misinformation is itself an episodic memory task, something that is often problematic for older adults. Other tasks yielding increased suggestibility in older adults (e.g., the DRM and false fame paradigms) are less dependent on episodic retrieval of the suggested event.

Relating Effects of Story Reading to Psychometric Measures

The psychometric test scores collected from the healthy older and DAT participants (see Table 1) can be used to help understand the mechanisms underlying story effects. For example, if suggestibility depends on encoding and retrieving the misinformation, then we would expect tests that tap episodic memory ability to predict the suggestibility effect. On the other hand, if activating semantic concepts matters, we would expect tests that tap semantic memory ability to predict effects of story exposure.

The psychometric test results were condensed into three scores theorized to reflect the underlying constructs of interest (on the basis of Kanne, Balota, Storandt, McKeel, & Morris, 1998). All psychometrics were standardized across all subjects. We averaged the Logical Memory and Associate Learning scores into a single episodic memory score, the Category Fluency and Boston Naming Test scores into a single semantic memory score, and the Mental Control, Backward Digit Span, and Word Fluency scores into a measure of frontal functioning.

Of interest was how these variables predicted positive and negative effects of story exposure. We investigated only the degree to which psychometric scores were related to cued recall performance, as that was the only task included in both experiments (and thus was associated with a larger sample size). To further increase power in these analyses, we collapsed across the two different experiments. Two analyses were done to predict subjects' proportion of correct answers after they had read the correct answers to easy and hard questions, and two were done to predict their proportion of misinformation answers after they had read these in the stories. To take into account baseline differences in knowledge, we always entered the proportion of correct answers on neutral questions in the first step of the regression analysis. On the second step, we examined the unique contributions of the episodic, semantic, and frontal factors. A dummy variable (also with a mean of 0) was entered in the second step to represent the two groups of subjects (DAT vs. healthy).

The results are shown in Table 7. It is noteworthy that once performance on neutral questions had been accounted for, subjects' different abilities predicted the benefits versus the costs of story reading.

When predicting subjects' ability to correctly answer questions, what mattered was semantic memory ability, for both easy questions, $t = 3.22$, $p = .002$, and hard questions, $t = 2.73$, $p = .007$. This suggests that the benefits of story reading were due to activation of semantic concepts. CDR scores explained no additional unique variance.

A different pattern was observed for misinformation production. For easy questions, what was critical was frontal functioning, $t = 2.05$, $p < .05$. Reduced frontal functioning was associated with increased misinformation production. This suggests that to the extent that subjects' scores were higher in frontal functioning, they were able to use their preexisting knowledge to reject the misinformation. For hard questions, a different pattern was found. The role of frontal functioning was diminished, likely because for hard questions subjects had no preexisting knowledge on which to basis their evaluation of the misinformation. Instead, what mattered was episodic memory ability, $t = 2.45$, $p < .02$. Using misinformation to answer hard questions on the final test required the learning and retrieval of new associations rather than the activation of a preexisting semantic network.

Table 7
Betas Associated With Performance on Neutral Questions, the Episodic Score, the Semantic Score, and the Frontal Score

Factor	Easy questions	Hard questions
Correct		
Neutral	.46*	.58*
CDR[a]	.01	.12
Episodic	.04	.13
Semantic	.37*	.28*
Frontal	.04	−.03
Misinformation		
Neutral	.18*	.20*
CDR[a]	.16	.16
Episodic	.17	.29*
Semantic	.18	.12
Frontal	−.20*	−.01

Note. Episodic score was the mean standardized performance on Associate Memory and Logical Memory subscales; semantic score was the mean standardized performance on Boston Naming Test and Category Fluency; and frontal score was the mean standardized performance on Mental Control, Backward Digit Span, and Word Fluency Test.
[a] For the Clinical Dementia Rating (CDR) Scale, dementia of the Alzheimer type was coded as −1, and healthy was coded as 1. Neutral scores were entered in the first step of the regression; all other scores were entered simultaneously on the second step.
* $p < .05$.

General Discussion

We examined the effects of reading fact-filled stories on the ability of younger adults, healthy older adults, and early-stage DAT individuals to answer general knowledge questions. Healthy older adults showed both positive and negative effects of story exposure. They often benefited as much from story reading as did younger adults and were actually less suggestible than the younger adults. DAT subjects showed the smallest effects of story reading; they produced less misinformation and were less aware of the story source.

The psychometric data suggest a mechanism for the benefits of story reading; crucial to the effect was activation of existing semantic concepts. Reading that Moscow is the capital of Russia activated those concepts in memory and strengthened the association between the two. The coactivation and association of concepts during story reading later allowed the retrieval of the answer in response to the cued recall question. To the extent that semantic concepts were preserved (as measured by Category Fluency and Boston Naming scores), positive effects of story reading occurred. It is noteworthy that benefits of story reading occurred in DAT subjects, as they are impaired on some semantic memory tasks (e.g., Salmon et al., 1999) but perform normally on others.

This is not to say, however, that the semantic networks of the DAT individuals were the same as those of subjects in other groups. For both younger and healthy older adults, having read misinformation not only led to its later production but also reduced subjects' correct answers below baseline. This reduction below baseline suggests that the misinformation sometimes conflicted with subjects' prior knowledge. Both younger and healthy older adults failed to correctly answer questions that they likely would have been able to answer if they had not read the misinformation. In contrast, having read misinformation did not decrease correct answers below baseline among DAT subjects. This suggests that the misinformation was not established in DAT subjects' semantic networks when they had already stored the correct answer.

Coactivation of semantic concepts, although important, cannot explain the salient group differences in production of target misinformation. First, subjects with lower frontal scores were more likely to produce misinformation as answers to easy questions. Frontal functioning may have allowed subjects to detect and avoid more blatant misinformation. In contrast, frontal functioning did not predict misinformation production for hard questions; subjects' lack of relevant knowledge for hard items meant that evaluating the misinformation would have been impossible (and thus frontal functioning was uninvolved). Nor was this misinformation preestablished in the semantic network as a competitor to the correct answer. Rather, answering hard questions with misinformation required the formation and retrieval of novel associations. As such, episodic memory ability predicted production of misinformation as answers to hard questions.

The above framework helps to explain one surprising finding, namely, that older adults were less suggestible than younger adults. This is in contrast to findings from many other laboratory paradigms in which older adults are more suggestible than are younger adults. In other paradigms, memory illusions arise from a misinterpretation of familiarity (e.g., false fame; Dywan & Jacoby, 1990), a source error (e.g., Lindsay & Johnson, 1989), or a failure to monitor activation (e.g., Balota, Cortese, et al., 1999). In our study, neither fluency nor source misattribution led to suggestibility. Instead, the subjects with the best source memory (the younger adults) were the most suggestible. In prior research in our lab, younger adults often showed a hindsight bias for facts learned in the stories (Marsh et al., 2003). That is, they knew the facts were in the stories, but they also erroneously believed they knew them before the experiment. Given this incorrect belief, we suggest that good memory for the story source does not preclude treatment of story items as facts. And older adults' presumably stronger knowledge base did not buffer them from the effects of story reading, because they showed the same costs from misinformation (in terms of reduction from the neutral baseline) as did younger adults. Rather, older adults appeared to be less suggestible because they were less able to remember the misinformation; this memory illusion was the strongest in the subjects with the best episodic memory abilities.

We end with a more general comment on the relationship between episodic and semantic memory. Performance on semantic tasks (e.g., Boston Naming) predicted benefits of story reading, whereas performance on episodic memory tasks (e.g., Logical Memory and Associate Learning) predicted misinformation production. This pattern supports Tulving's (1972) conception of separate semantic and episodic memory systems. Although we used the labels *semantic* and *episodic* to group our tasks (and this grouping was based on prior work by Kanne et al., 1998), it should be noted that both classes of tasks are dissociable. That is, patterns can be found whereby individuals do well on one semantic (or episodic) memory task but not on another. Even though a group of tasks are all labeled *semantic* (or *episodic*) and have a documented relationship to one another, they likely still have component processes that can be uncorrelated. The point is that DAT individuals may have some processes and not others intact, leading to a pattern whereby they perform normally on some tasks but not on others even if all are labeled *semantic memory tasks.* In short, although the current data suggest that DAT individuals have some semantic concepts available, that does not preclude their having problems on other semantic memory tasks that draw on different component processes.

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Appendix

Sample Story Paragraph and Test Questions

Excerpt From the Inventor Story

So that fact framing could be manipulated across subjects, the capital of Russia was read as "Moscow" or "St. Petersburg" or left unnamed.

> It was a crisp fall day, Billy was ten years old and in Ms. Pringle's fifth grade class. The day began as a normal Friday—everyone was talking about their weekend plans, and planning their costumes for the upcoming Halloween parties. But everything changed for Billy when Ms. Pringle made her announcement:
>
> "Boys and girls! Your attention please! I have exciting news." She paused, waiting for the students' full attention. "I'm happy to announce that this year's science fair will be held just three short weeks from today." She held up her hand to stop the groans from the children. "Now class, you know this can be fun. To help motivate you, we have a special prize this year—the winner of the science fair will win a trip to the national contest, which will be held in the capital of Delaware. And the winner of that contest will get to go [to the international science fair in Moscow, the capital of Russia!/to the international science fair!/to the international science fair in St. Petersburg, the capital of Russia!]."

Sample Test Questions

In Experiment 1, subjects answered only cued-recall questions. In Experiment 2, subjects answered cued recall, two-alternative forced choice (2AFC), and source questions.

> Cued recall: What is the capital of Russia?
>
> 2AFC: What is the capital of Russia, Moscow or St. Petersburg?
>
> Source: Did you read that answer in the story, yes or no?

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