Neuropsychology
2005, Vol. 19, No. 4, 411–419

0894-4105/05/$12.00 DOI: 10.1037/0894-4105.19.4.411

Comparing Source-Based and Gist-Based False Recognition in Aging and Alzheimer's Disease

Benton H. Pierce
Harvard University

Alison L. Sullivan
Brigham and Women's Hospital

Daniel L. Schacter
Harvard University

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

This study examined 2 factors contributing to false recognition of semantic associates: errors based on confusion of source and errors based on general similarity information or gist. The authors investigated these errors in patients with Alzheimer's disease (AD), age-matched control participants, and younger adults, focusing on each group's ability to use recollection of source information to suppress false recognition. The authors used a paradigm consisting of both deep and shallow incidental encoding tasks, followed by study of a series of categorized lists in which several typical exemplars were omitted. Results showed that healthy older adults were able to use recollection from the deep processing task to some extent but less than that used by younger adults. In contrast, false recognition in AD patients actually increased following the deep processing task, suggesting that they were unable to use recollection to oppose familiarity arising from incidental presentation.

Keywords: Alzheimer's disease, false recognition, recollection, source memory

Although memory is often accurate, various types of distortions and false memories frequently occur (Schacter, 1999, 2001). One type of false memory that has been extensively studied is false recognition, in which one erroneously claims to have previously encountered a novel word or event. The ability to minimize memory errors such as false recognition is a critical component of normal memory functioning (Schacter, 1996, 2001). Laboratory methods designed to minimize or suppress false recognition have been explored in healthy older adults (Kensinger & Schacter, 1999) and in patients with various types of brain damage (Budson, Daffner, Desikan, & Schacter, 2000; Budson, Sullivan, et al., 2002; Schacter, Verfaellie, Anes, & Racine, 1998) through repeated presentations of study and test materials. Other studies have examined suppression of false recognition via the use of a distinctiveness heuristic, in which the absence of expected distinctive information results in correct rejection of novel items that would otherwise elicit false alarms (Budson, Sitarski, Daffner, & Schacter, 2002; Israel & Schacter, 1997; Schacter, Israel, & Racine, 1999). These studies have helped us to better understand the neuropsychology of memory failure in specific brain diseases and the prevalence of clinically relevant memory distortions in certain patient populations, as well as having provided insights into normal memory function in younger and older adults.

Another method of suppressing false memories was explored by S. M. Smith, Tindell, Pierce, Gilliland, and Gerkens (2001). They used an experimental paradigm in which recollection of source information could be used to avoid intruding incidentally presented exemplars from categorized lists. In the S. M. Smith et al. study, participants first performed an incidental orienting task in which they either deeply processed words (by assigning pleasantness ratings) or shallowly processed words (by counting vowels). Participants then intentionally studied a series of categorized word lists (e.g., *birds, fruit, furniture*) in which the most typical category members (e.g., *robin, orange, chair)* were omitted. Of importance, some of these critical nonpresented category members had appeared in the incidental task. Finally, participants were given a cued-recall test, in which they were provided category names as cues. Two dependent measures were of primary interest: (a) intrusions of critical items that had appeared in the incidental task and (b) intrusions of critical items that had not appeared in the incidental task. We view the first type of intrusions as source-based memory errors, because although participants correctly remember the item, they misattribute its source (Johnson, Hashtroudi, & Lindsay, 1993). The second type of intrusions represents errors that are likely due to reliance on general similarity or gist information (e.g., Reyna & Brainerd, 1995), because participants correctly remember the semantic gist of the studied category but are

Benton H. Pierce and Daniel L. Schacter, Department of Psychology, Harvard University; Alison L. Sullivan, Division of Cognitive and Behavioral Neurology, Department of Neurology, Brigham and Women's Hospital, Boston; Andrew E. Budson, Division of Cognitive and Behavioral Neurology, Department of Neurology, Brigham and Women's Hospital, and Harvard Medical School.

Andrew E. Budson is now at the Geriatric Research Education Clinical Center, Edith Nourse Rogers Memorial Veterans Hospital, Bedford, Massachusetts; Department of Neurology, Boston University Alzheimer's Disease Research Center, Boston University School of Medicine, Boston; and Division of Cognitive and Behavioral Neurology, Department of Neurology, Brigham and Women's Hospital.

This research was supported by National Institute on Aging Grants AG0844 and P30AG13846 and National Institute of Mental Health Grant K23 MH01870. We thank Hyemi Chong for her assistance in testing participants and Amy Wiseman, David Gallo, and Elizabeth Kensinger for their invaluable help and support.

Correspondence concerning this article should be addressed to Benton H. Pierce, who is now at the Department of Psychology and Special Education, Texas A&M University—Commerce, Commerce, TX 75429. E-mail: benton_pierce@tamu-commerce.edu

unable to use specific details of their prior encounter with particular items (item-specific recollection) to distinguish which category exemplars were studied and which were not. When participants were specifically told to exclude incidentally presented items in the study of S. M. Smith et al., they decreased their false recall of critical items—but only for the more deeply processed items (Experiment 1). S. M. Smith et al. suggested that accurate recollection of source information for the deeply processed items could be used to oppose false recall of incidentally presented critical items when participants were specifically instructed to exclude these items.

We were interested in investigating the effects of aging and Alzheimer's disease (AD) on this type of false memory suppression by adapting the S. M. Smith et al. (2001) paradigm to examine two types of false recognition: that based on gist influences and that based on source confusion. Gist-based false recognition has been examined extensively in older adults and patients with AD, primarily through the use of a paradigm developed by Deese (1959) and later revived and modified by Roediger and McDermott (1995). In the Deese–Roediger–McDermott (DRM) paradigm, participants study lists of words (e.g., *candy, sour, sugar, taste,* and so forth) that are all semantically associated with a nonpresented lure (e.g., *sweet*). Numerous studies have revealed that older adults often exhibit relatively higher levels of false recognition to such lures compared with younger adults (e.g., Balota et al., 1999; Kensinger & Schacter, 1999; Norman & Schacter, 1997; Tun, Wingfield, Rosen, & Blanchard, 1998). In contrast, several studies have shown that false recognition of semantically related lures is significantly lower in patients with AD than in healthy older adults (after controlling for false alarms to unrelated lures; Balota et al., 1999; Budson et al., 2000; Budson, Sitarski, et al., 2002; Budson, Sullivan, Daffner, & Schacter, 2003). Of importance for the present research, previous studies have demonstrated that although healthy older adults are able to suppress false recognition of semantic associates under certain circumstances (such as when using a distinctiveness heuristic, Schacter et al., 1999, or with repeated study sessions, Budson, Sullivan, et al., 2002), under other circumstances they are less able to do so, compared with younger adults (such as with repeated study–test trials, Kensinger & Schacter, 1999; cf. Budson et al., 2000). Given the varying results of previous research concerning false recognition suppression in older adults, it was of particular interest to evaluate whether healthy older adults would be able to suppress false recognition with the present paradigm. Patients with AD, in contrast, have shown no ability to suppress false recognition of semantic associates using a distinctiveness heuristic (Budson, Sitarski, et al., 2002), repeated study sessions (Budson, Sullivan, et al., 2002), or repeated study–test trials (Budson et al., 2000). In fact, these very manipulations that reduced false recognition in healthy younger and older adults actually increased the false recognition of semantic associates in these patients. Given these previous results, we were interested in both whether our patients with AD could use recollection of source information to suppress false recognition of categorized list items and, if not, whether such source information would actually increase their false recognition. Before discussing our predictions for the older adults and the patients with AD, we briefly review the relevant literature.

In addition to showing reduced false recognition of semantic associates from DRM word lists, AD patients show reduced false recognition of perceptually related novel objects (Budson, Desikan, Daffner, & Schacter, 2001), categorized color photographs (Budson, Michalska, et al., 2003), and phonologically related words (Budson, Sullivan, et al., 2003). Budson and colleagues (Budson et al., 2001; Budson, Michalska, et al., 2003; Budson, Sullivan, et al., 2003) have suggested that this consistent pattern of reduced false recognition in AD patients across various experimental paradigms results from the patients' impairment in acquiring, retaining, or retrieving general similarity or gist information (e.g., Reyna & Brainerd, 1995). As mentioned above, gist information can be contrasted with recollection of a prior encounter with a particular item (item-specific recollection). Accurate recognition of previously studied items likely depends on both item-specific and gist information, whereas false recognition of semantically or perceptually related lure items depends on remembering gist but not item-specific information. Older adults, in contrast to patients with AD, do not show impaired gist information but do show impaired item-specific recollection, which several authors have argued is the cause of their elevated levels of false recognition relative to younger adults (Budson, Sullivan, et al., 2003; Koutstaal & Schacter, 1997; Norman & Schacter, 1997).

In comparison to gist-based false recognition in AD patients, false recognition arising from source confusion has received somewhat less attention. Source memory deficits in the AD patient population have been documented in a number of studies (Dalla Barba, Nedjam, & Dubois, 1999; Dick, Kean, & Sands, 1989; Mitchell, Hunt, & Schmitt, 1986; Multhaup & Balota, 1997; J. A. Smith & Knight, 2002; Tendolkar et al., 1999). For example, Multhaup and Balota (1997) found that AD patients were impaired at discriminating information they had read from information they had generated themselves, and Dalla Barba et al. (1999) observed impairments in AD patients' ability to discriminate seen from imagined objects. These examples of source memory impairments suggest that AD patients may be particularly susceptible to the type of source-based false recognition examined in the current paradigm. Source memory is also impaired in older adults relative to younger adults, as has been shown in numerous studies (e.g., Ferguson, Hashtroudi, & Johnson, 1992; Henkel, Johnson, & De Leonardis, 1998; McIntyre & Craik, 1987; Schacter, Kaszniak, Kihlstrom, & Valdiserri, 1991; Schacter, Koutstaal, Johnson, Gross, & Angell, 1997; Spencer & Raz, 1995; Trott, Friedman, Ritter, Fabiani, & Snodgrass, 1999). The source memory deficits of older adults are not, however, as severe as those of patients with AD (Dalla Barba et al., 1999; Dick et al., 1989; Mitchell et al., 1986; Multhaup & Balota, 1997; J. A. Smith & Knight, 2002; Tendolkar et al., 1999).

In summary, previous studies show that older adults are impaired in source memory but not in gist memory, whereas patients with AD are impaired in gist memory and even more impaired in source memory than are healthy older adults. In addition, previous research has shown that young adults are able to use recollection of source information to oppose automatic or familiarity-based processes (e.g., Jacoby, 1991; Jacoby, Woloshyn, & Kelley, 1989; Jennings & Jacoby, 1997). Furthermore, source recollection in younger adults is enhanced when items are deeply processed (Mulligan & Hirshman, 1997; S. M. Smith et al., 2001). We therefore suspected that, in contrast to younger adults, both older adults and patients with AD would show difficulty in using source memory to suppress gist-based false recognition but that the AD patients would show greater difficulty. We predicted that prior exposure to a critical item would increase levels of false recognition for the patients with AD, regardless of the depth of processing or number of repetitions.

In discussing gist- and source-based false recognition, it is important to note that source-based false memories often contain a gist-based or semantic component (S. M. Smith et al., 2001) and also that false recognition of semantic lists can occur through source confusion as well as through reliance on gist. For example, source-based misattribution errors usually do not occur unless the misattributed item or event is a plausible response (S. M. Smith, Ward, Tindell, Sifonis, & Wilkenfeld, 2000). And false recognition of semantic associates, particularly in the DRM paradigm, may be due to source confusion of implicit associative responses generated at study (Bousfield, Whitmarsh, & Danick, 1958; Deese, 1959; Koutstaal & Schacter, 1997; Underwood, 1965). Therefore, we adapted our paradigm to allow us to examine five separate types of false recognition and to compare them both within and across groups. The first type is purely gist based, in which critical lures have no source component. The second type of false recognition involves a combination of gist and high-recollection source components. The high-recollection aspect involved an incidental deep processing task with repeated exposures to critical lures. In the third type of false recognition, we examined errors containing both source and gist components but in a condition involving an incidental shallow processing task in which source recollection was expected to be minimal. Finally, we examined false recognition errors that have no gist-based component (i.e., pure source-based errors). We hoped that the use of this paradigm in these populations would enable us to better understand the interaction between gist- and source-based false recognition in normal memory, aging memory, and memory impaired by AD. Table 1 depicts the various types of false recognition examined and examples of each.

Method

Participants

Twelve patients with a clinical diagnosis of probable AD (based on National Institute of Neurologic and Communicative Disorders and Stroke—Alzheimer's Disease and Related Disorders Association criteria; McKhann et al., 1984), 24 healthy older adults, and 12 younger adults participated in the experiment. Patients with AD were recruited from the clinical population at the Memory Disorders Unit, Brigham and Women's Hospital. Healthy older adults were recruited from participants in a longitudinal study of normal aging at Brigham and Women's Hospital, from spouses and friends (but not blood relatives) of the patients, as well as through flyers posted at Harvard University and at senior centers in and around Boston. Younger adults were recruited through flyers posted at Harvard University. Participants were interviewed to exclude those with any of the following conditions: a history of alcoholism or substance abuse, cerebrovascular accident, recent myocardial infarction, present or previous treatment for psychiatric illness, current treatment with psychoactive medication, metabolic or drug toxicity, other degenerative disorders (e.g., Parkinson's disease or Huntington's disease), and brain damage from another known cause (e.g., hypoxia, trauma). Written informed consent was obtained from all participants and their caregivers (when appropriate). The study was approved by the human subjects committees of Brigham and Women's Hospital and Harvard University. All participants were paid $10 per hour for their participation. The patients showed mild impairment on the Mini-Mental State Examination (Folstein, Folstein, & McHugh, 1975), with no one scoring below 21 (M = 25.8, range = 21–29). All participants had normal or corrected-to-normal vision and hearing. The patients were matched to the older adults on the basis of age (AD patients, M = 75.8 years, range = 60–84; older adults, M = 74.9 years, range = 69–85) and had similar levels of education (patient, M = 15.4 years, range = 12–24; older adults, M = 17.0 years, range = 12–23). The ages of the younger adults ranged from 18 to 24 years, with a mean of 19.9 years.

Materials and Design

Twelve categorized word lists (e.g., *fruit, birds*) were selected from the Battig and Montague (1969) norms and from S. M. Smith et al. (2000). For the study lists, two sets of six 12-item word lists were chosen, Set A and Set B. For each list, three common category members (e.g., *apple, orange, and banana*) were omitted and served as critical lure items. Half the participants studied lists from Set A, and the other half studied lists from Set B. List order was randomized and kept constant for all participants. Within each list, study words were presented in the same random order to each participant. For the deep and shallow incidental orienting tasks, 24 filler words were chosen that matched the study list critical words with respect to word frequency. The filler words were divided into two sets of 12 words each, corresponding to Sets A and B of the study lists. Along with the 12 filler words, a critical lure item from each of the six studied categories was included, resulting in a 18-item word list for each incidental task. The three critical items from each category were divided into three types: (a) deeply processed items (e.g., *apple*), (b) shallowly processed items (e.g., *orange*), and (c) items not presented in either incidental task (e.g., *banana*). Each critical item served as a deeply processed, shallowly processed, and nonpresented item an equal number of times. In addition, the order of the manner in which critical and filler items were processed

Table 1
Type of False Recognition Examined

Item description	Response at test	Item type	False recognition type
Semantically related but not incidentally presented (e.g., *banana*)	"old"	Critical lure	Pure gist based
Semantically related and shallowly processed in incidental task (e.g., *orange*)	"old"	Critical lure	Shallow source plus gist
Semantically related and deeply processed in incidental task (e.g., *apple*)	"old"	Critical lure	Deep source plus gist
Semantically unrelated and shallowly processed in incidental task (e.g., *library*)	"old"	Filler	Pure source based (shallow)
Semantically unrelated and deeply processed in incidental task (e.g., *pencil*)	"old"	Filler	Pure source based (deep)

Note. Critical lure examples are from the Fruit list.

(deep or shallow) was counterbalanced between participants, resulting in six separate counterbalancing orders within each of the two incidental–study list sets, or 12 orders overall.

The main design consisted of a within-group variable, *critical lure type* (pure gist based, shallow source, and deep source), and a between-groups variable, *group* (AD patients vs. older adults vs. younger adults). We also analyzed pure source-based recognition of the filler items (shallow source and deep source) as a function of group.

Procedure

Participants were tested individually. All stimuli were presented on Apple MacIntosh computers. The experiment consisted of four parts in three phases, as follows:

Phase 1: Shallow and deep processing tasks

Shallow processing task—6 critical items and 12 filler items (e.g., “How many *e*s in *orange*?”)

Deep processing task—6 critical items and 12 filler items (e.g., “Johnny’s mom packed an *apple* in his lunch box” with the corresponding question “Does this sentence make sense?”)

Order of tasks was counterbalanced between participants.

Phase 2: Study of six categorized lists (e.g., fruit, birds, sports)

Top three exemplars were omitted from each list.

Phase 3: Recognition test

True targets (from studied lists)

True target controls (from nonstudied lists)

Critical lures

Shallow source plus gist (e.g., *orange*)

Deep source plus gist (e.g., *apple*)

Pure gist (e.g., *banana*)

False target controls (critical lures from nonstudied lists)

Filler items from shallow processing task (e.g., *library*)

Filler items from deep processing task (e.g., *pencil*)

The first two parts involved the shallow and deep incidental orienting tasks. The shallow task consisted of counting the number of *e*s in each word on the incidental list, including six critical lures from lists that were later studied in the third part and 12 filler words. Six of the 12 filler items were later tested. The deep orienting task consisted of a series of sentence frames containing a highlighted word at the end, which participants judged as either congruent or incongruent with the sentence frame. The highlighted words included another six critical lures from the later studied lists, along with 12 filler words. Again, six of these filler items were later tested. For each critical item and filler item that was later tested, sentence frames were created that were congruent with the item. To maximize the efficacy of the deep orienting task, we created three separate sentence frames for each critical item and filler that was later tested, so that participants processed these items three times. For filler items that were not tested, sentence frames were created that were incongruent with the item, and the same sentence–word frame was presented three times. This resulted in a total of 36 congruent and 18 incongruent sentence–word combinations in the deep orienting task. Participants read each sentence–word frame aloud as it appeared on a computer screen.

In the third part, participants studied six categorized lists in blocks of 12 items each, saying each word aloud as it appeared on the screen. During both incidental tasks, stimuli were shown until the participants gave a verbal response that the experimenter entered on the keyboard. For the study task, list items were presented one word at a time for 3 s each, with a 1-s interval between words. After all 12 items of each list were presented, a fixation cross appeared in the middle of the screen, indicating that the list was finished and the next list was about to be presented.

Finally, participants were given a 96-item recognition test, presented in a different random order for each counterbalancing condition. The test consisted of 36 studied target items, 12 target controls from nonstudied lists, 6 critical lures from the shallow orienting task, 6 critical lures from the deep orienting task, 6 critical lures that were not presented in either incidental task, 18 false target controls or unrelated lures (the critical lures from each of 6 nonstudied lists), 6 filler items from the shallow orienting task, and 6 filler items from the deep orienting task. Before the test, participants were told that some of the test words were from the incidental tasks, which meant that they could not have been included in the studied lists. Therefore, participants were instructed to say “new” to any words that they remembered from the *e*-counting task or from the sentence judgment task. To assist participants in recollecting the source of the incidentally presented words, we had them perform the incidental tasks in one room and then change rooms for the study and test phases.

Results

Table 2 shows the proportion of “old” responses to true targets, true target controls, the three types of critical lures (shallow source, deep source, and nonpresented), false target controls, and the two types of filler items (shallow source and deep source) as a function of group (AD patients, older adults, and younger adults). Table 2 also presents corrected true recognition (obtained by subtracting the proportion of “old” responses to true target controls from the proportion of “old” responses to true targets) and corrected false recognition of filler items (obtained by subtracting the proportion of “old” responses to false target controls from the proportion of “old” responses to filler items). False recognition for critical items was corrected in the same way as it was for filler items and is depicted in Figure 1. Compared with older adults, AD patients made significantly more false alarms to true target controls, $F(1, 34) = 16.48$, $MSE = 0.030$, $p < .01$, and to false target controls, $F(1, 34) = 22.43$, $MSE = 0.034$, $p < .01$. Therefore, all between-groups analyses were conducted on corrected true and false recognition scores.

True Recognition: True Targets Minus True Target Controls

As can be seen in Table 2, AD patients exhibited significantly lower levels of corrected true recognition than did healthy older adults, $F(1, 34) = 62.60$, $MSE = 0.032$, $p < .01$. True recognition did not differ between the older and younger adults, $F(1, 35) < 1$.

False Recognition: Critical Lures Minus False Target Controls

AD patients versus older adults. Figure 1 depicts the three types of corrected false recognition in the three groups. We first compared false recognition in AD patients and older control par-

Table 2
Proportion of "Old" Responses on the Recognition Test as a Function of Item Type and Group

	Group					
	AD patients		Older adults		Younger adults	
Item type	*M*	*SD*	*M*	*SD*	*M*	*SD*
True targets	.67	.20	.93	.07	.86	.06
True target controls	.30	.25	.05	.12	.01	.03
True recognition (corrected)	**.37**	.24	**.87**	.14	.85	.04
Critical lures						
Nonpresented (gist)	.58	.23	.40	.31	.33	.27
Shallow source plus gist	.67	.24	.49	.34	.43	.24
Deep source plus gist	.85	.25	.41	.30	.25	.19
Filler items (pure source)						
Shallow	.51	.29	.03	.08	.04	.10
Deep	.65	.32	.03	.07	.00	.00
False target controls	.38	.27	.07	.13	.04	.05
False recognition (corrected)						
Filler items (shallow)	**.13**	.17	**−.04**	.14	.01	.07
Filler items (deep)	**.27**	.36	**−.04**	.16	−.04	.05

Note. Numbers in boldface represent significant differences between groups; significant differences are reported for corrected values only. AD = Alzheimer's disease.

ticipants. A 3 (critical lure type) × 2 (group: AD patients vs. older adults) mixed analysis of variance (ANOVA) showed a main effect of critical lure type, $F(2, 68) = 4.10$, $MSE = 0.039$, $p < .05$. Critical lures that had been shallowly processed in the incidental orienting task were falsely recognized more often than were lures that had not been presented in the incidental task (pure gist-based lures), $F(1, 34) = 4.77$, $MSE = 0.027$, $p < .05$. Likewise, lures that had been deeply processed in an incidental task were falsely recognized more often than were gist-based lures, $F(1, 34) = 6.46$, $MSE = 0.048$, $p < .05$. The shallow-source and deep-source lures did not differ from each other, $F(1, 34) < 1$.

Of more importance was the presence of a significant Critical Lure Type × Group interaction, $F(2, 68) = 4.55$, $MSE = 0.039$, $p < .05$ (see Figure 1). Because this interaction was difficult to interpret, we conducted a series of 2 (critical lure type) × 2 (group) mixed ANOVAs. An ANOVA comparing gist-based critical lures to shallow-source lures across the two groups (AD patients and older adults) found no Critical Lure Type × Group interaction, $F(1, 34) < 1$. A second ANOVA comparing gist-based lures to deep-source lures revealed a significant Critical Lure Type × Group interaction, $F(1, 34) = 5.25$, $MSE = 0.048$, $p < .05$. Pairwise comparisons showed that AD patients falsely recognized

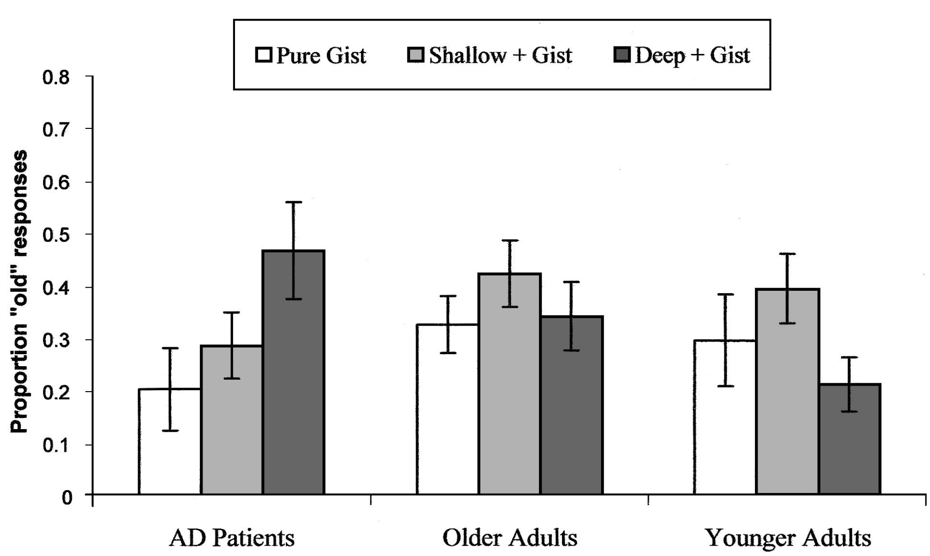

Figure 1. Corrected false recognition of critical lures as a function of lure type and group. Error bars represent standard error of the mean. AD = Alzheimer's disease.

deep-source lures at a higher rate than they did pure gist-based lures, $t(11) = 2.99$, $SEM = 0.088$, $p < .05$, whereas false recognition for these two types of lures did not differ for older adults, $t(23) < 1$.

A third ANOVA comparing shallowly and deeply processed critical lures between groups found no main effect of lure type, $F(1, 34) < 1$, but a significant Critical Lure Type × Group interaction, $F(1, 34) = 6.75$, $MSE = 0.041$, $p < 05$. For AD patients, false recognition of deep-source lures was greater than that of shallow-source lures, $t(11) = 2.40$, $SEM = 0.075$, $p < .05$. In contrast, older adults showed numerically lower levels of false recognition of deep-source lures than of lures that had been shallowly processed, although this difference was not significant, $t(23) = 1.37$, $p = .19$. These results suggest that for AD patients, repeated deep processing of critical items in an incidental task served only to increase the items' familiarity, with no corresponding increase in recollection that would allow the patients to reject these lures at test.

We also compared levels of gist-based false alarms in AD patients and older adults. Although gist-based false recognition was numerically lower in AD patients than in older adults (.20 vs. .33, respectively), this difference was not significant, $F(1, 34) = 1.67$, $MSE = 0.072$, $p = .21$.

Older adults versus younger adults. Last, we compared younger and older adults on false recognition of the three critical lure types. A 3 (critical lure type) × 2 (group: younger adults vs. older adults) mixed ANOVA revealed a main effect of critical lure type, $F(2, 68) = 3.56$, $MSE = 0.042$, $p < .05$. Shallowly processed critical items were falsely recognized more often than were deeply processed lures, $F(1, 34) = 7.19$, $MSE = 0.039$, $p < .05$, and the effect was in the same direction for both groups. Although the Critical Lure Type × Group interaction was not significant, $F(2, 68) < 1$, it should not be interpreted to mean that both groups were able to use source recollection to the same extent from the deep processing task to lower false recognition below that resulting from shallow processing. The previous analysis comparing AD patients and older adults showed that older adults' false recognition of deeply processed critical items was numerically, but not significantly, lower than their false recognition of shallowly processed items. Younger adults were able to significantly lower false recognition of deep-source lures below that of shallow source lures, $t(11) = 2.72$, $SEM = 0.067$, $p < .05$, suggesting that the main effect of lure type was driven primarily by the younger adults.

False Recognition: Incidentally Presented Filler Items

We also analyzed false recognition of items presented in the incidental orienting tasks that were unrelated to any of the categories that participants later studied. Because these filler items contained no gist-based component, false alarms to the items can be considered a measure of pure source-based false recognition. As with our analysis of critical lure false recognition, we subtracted the proportion of "old" responses to false target controls from the proportion of "old" responses to the filler items. As can be seen in Table 2, corrected false recognition of the incidentally presented filler items was substantial for AD patients in both the shallow and deep encoding conditions, whereas false recognition was essentially zero for older and younger adults. A 2 (filler item type) × 2 (group: AD patients vs. older adults) mixed ANOVA confirmed that AD patients falsely recognized the incidentally presented filler items more often than did older adults, $F(1, 34) = 15.19$, $MSE = 0.060$, $p < .01$. Although the Filler Item Type × Group interaction was nonsignificant, $F(1, 34) = 3.52$, $MSE = 0.022$, $p = .069$, pairwise comparisons showed that false recognition of filler items was significantly higher in AD patients than in older adults when the items had been shallowly processed, $F(1, 34) = 9.88$, $MSE = 0.023$, $p < .01$, as well as when they had been deeply processed, $F(1, 34) = 12.92$, $MSE = 0.059$, $p < .002$. False recognition of shallowly and deeply processed filler items did not differ between younger and older adults, $Fs(1, 34) < 1$.

Discussion

Previous studies examining false recognition in AD patients have focused either on errors based on general similarity or gist information (e.g., Balota et al., 1999; Budson et al., 2000; Budson, Sitarski, et al., 2002; Budson, Sullivan, et al., 2003) or on errors due to source memory confusion (e.g., Budson, Sullivan, et al., 2002; Dalla Barba et al., 1999; Multhaup & Balota, 1997). The present study extended this research to include errors based solely on gist influences, those based solely on source confusion, and those based on a combination of gist and source confusion. We used a categorized list paradigm (S. M. Smith et al., 2001) that allowed us to directly compare all three types of errors in AD patients, older adults, and younger adults within the same experimental setup.

Examination of critical lures containing both gist and source components indicates that for AD patients, shallow processing of critical lures in the incidental orienting task (i.e., shallow-source plus gist lures) produced a pattern similar to that observed in older adults. False recognition of shallowly processed critical lures was greater than that of pure gist-based lures in both groups. In fact, even younger adults showed this pattern, suggesting that for all three groups, shallow processing of these items increased their familiarity but had minimal impact on source recollection that could be used to oppose this familiarity.

In contrast, a different pattern emerged for deeply processed critical items that also contained a gist component. In a condition that was designed to maximize recollection (deep processing and multiple exposures), AD patients falsely recognized critical lures significantly more often than they did pure gist-based lures. In contrast, older adults falsely recognized these two types of critical lures at nearly identical rates, whereas younger adults made nonsignificantly fewer false alarms to deeply processed lures than to gist-based lures. This pattern suggests that, as we predicted, for AD patients the deep processing task imparted little or no source recollection for the critical lures. Instead, the task appeared to increase the familiarity of these items, which when unopposed by source recollection, resulted in substantial source-based false recognition. Also as predicted, older adults were similarly unable to use source recollection to lower gist-based false recognition. Their false alarms to deeply processed critical lures were virtually identical to their pure gist-based false alarms (.34 vs. .33, respectively). This is not to say that older adults had no recollection for deeply processed items. Inspection of Figure 1 shows that starting with gist-based false recognition, older adults' false recognition increased after shallow processing but then declined after deep processing. Therefore, compared with AD patients, older adults appeared to have some degree of source recollection that was used to oppose the increased familiarity of these items. Source recollection appeared to be greatest in younger adults, who made significantly fewer false alarms to deeply processed critical lures than to lures that had been shallowly processed and made numerically fewer false alarms to the deeply processed lures than to pure gist-based lures, although this difference was not significant.

Further support for the severe impairment in source recollection in AD patients comes from analysis of their false alarms to incidentally presented filler items (i.e., pure source-based lures). Although these items were not members of any studied categories, AD patients falsely recognized these items at an appreciable rate, particularly when the items had been deeply processed. In contrast, older and younger adults made virtually no false alarms to these items following either shallow or deep processing. For AD patients, incidental presentation of filler items apparently increased their familiarity, which was unopposed by source recollection. However, to the extent that AD patients were impaired in recalling the studied categories, it is also possible that deficits in acquiring or retaining gist information could have contributed to these false alarms. That is, the absence of false alarms to filler items in older and younger adults may reflect recollection of gist as well as source information. These participants may have reasoned: "This item is completely unrelated to any of the categories I just studied, so it must be a new item." This process would not have required that they recollect that the filler item had been presented in the incidental task. Therefore, the appreciable false recognition of filler items in AD patients may have been caused by a combination of deficits in recollecting both source and gist information. Our design did not allow us to tease apart these separate contributions to false recognition of filler items.

Two additional points deserve comment. First, contrary to our prediction, younger adults were unable to use the source information of the incidental lists to suppress gist-based false recognition. There are several reasons that, in combination, may explain this observation. One is that the finding may be attributable to inadequate power: There were nonsignificant trends suggesting that, in fact, younger adults may be able to suppress false recognition in the deep source condition, at least to a small extent (.30 for pure gist vs. .21 for deep source). Another reason may have been the low pure gist false-recognition rate observed with this categorized list paradigm, which was then difficult to further suppress. Paradigms using DRM lists typically show higher rates of false recognition than the rates observed in our study. A last reason, the difficulty of the task, including keeping track of the source of three separate study lists, may have made it difficult for participants to use the source information to reduce gist-based false recognition. Future studies with larger numbers of participants, using DRM lists instead of categorized lists, and using only a single list of incidental items will be better able to determine whether younger adults are able to use source information to reduce gist-based false recognition.

Second, for pure gist-based false recognition, AD patients made numerically fewer gist-based errors (on a corrected basis) than did older adults, although this difference was not significant. This finding may again result from the fact that differences in gist-based false recognition between these groups may be smaller when categorized lists rather than DRM word lists are used, because categorized lists do not produce as robust levels of false recognition compared with DRM lists. For example, in previous studies showing significantly lower gist-based false recognition in AD patients compared with older control participants (e.g., Balota et al., 1999; Budson et al., 2000; Budson, Sitarski, et al., 2002; Budson, Sullivan, et al., 2003), false recognition levels in older control participants were considerably higher ($M = .59$) than what we observed in the present study ($M = .33$).

In summary, we found that whereas none of the groups were able to use source information of incidentally presented items to significantly reduce gist-based false recognition, only the patients with AD showed rates of false recognition for deeply processed items that were significantly higher than rates of gist-based false recognition. The severe deficits in source recollection observed in these patients suggest that familiarity may be their only basis for making an "old" response. This familiarity from having encountered an item, despite conditions that were designed to increase source recollection (i.e., deep processing, multiple exposures, and change of environmental context), resulted in elevated source-based errors in AD patients, even when items were unrelated to categories that they had just studied. In the other groups, false recognition of deeply processed items was equal to or numerically lower than gist-based false recognition and also equal to or significantly lower than false recognition of shallowly processed items, suggesting that source recollection countered the influences of familiarity. In terms of AD, the present study extends prior work on false recognition in several areas. The numerical trends showing lower gist-based false recognition in patients compared with older control participants replicate previous findings (e.g., Balota et al., 1999; Budson et al., 2000; Budson, Sitarski, et al., 2002; Budson, Sullivan, et al., 2003). More important, we added two measures of source-based false recognition (i.e., following shallow and deep incidental encoding) to show that in AD patients, deep processing of critical items results in increased false recognition.

To compare the magnitude of the differences in the two types of false recognition between AD patients and older adults, we computed effect sizes between the two groups. For gist-based false recognition, $r = .217$, reflecting the extent to which these errors were lower in AD patients than in older adults. For source-based false recognition, we computed an effect size for the group difference in false alarms to the deeply processed filler items (i.e., pure source-based items). In this analysis, $r = .524$, indicating the extent to which pure source-based errors were higher in AD patients than in older adults. This difference in effect sizes suggests that in AD patients, source-based influences on false recognition are substantially greater than those based purely on gist, at least in the present experimental paradigm.

The elevated levels of source-based false recognition in AD patients are similar to a pattern found by Gallo, Sullivan, Daffner, Schacter, and Budson (2004), who examined associative recognition in mildly impaired AD patients and older control participants. Gallo et al. presented participants with unrelated word pairs once or three times and found that false alarms to rearranged pairs following repetition increased in the patients but not in the control participants. The authors suggested that control participants could use a recall-to-reject strategy to counter the increased familiarity of rearranged pairs, whereas AD patients could not. Likewise, in the present study, AD patients apparently could not use a recall-to-reject process when instructed, resulting in elevated levels of false recognition of items that had been made more familiar through the deep processing task.

Although much of the discussion of our results focuses on both the source-monitoring framework (Johnson et al., 1993) and the distinction between recollection and familiarity (e.g., Jacoby, 1991, 1999), our findings are also compatible with fuzzy-trace theory (e.g., Brainerd & Reyna, 2002; Brainerd, Reyna, Wright, & Mojardin, 2003). Fuzzy-trace theory proposes that experiences are encoded in two separate forms of memory traces. Verbatim traces capture the surface form of perceived items, including contextual or source information, and gist traces represent the general meaning or pattern that results from encoding these surface forms. Gist-based false recognition presumably arises from the semantic overlap between nonpresented lures and the studied lists (i.e., gist traces). Source-based false recognition, conversely, may result from the relative strength of both verbatim and gist traces. Deep processing (and repetition) of incidentally presented critical items may have strengthened their verbatim traces in younger adults, allowing them to reject these items at test. That is, younger adults could use a recall-to-reject strategy (Gallo et al., 2004) or an analogous process that Brainerd et al. (2003) termed *recollection rejection.* For AD patients, deeper processing of incidentally presented critical items may have increased their gist-based similarity to later studied lists, resulting in increased false recognition. From a fuzzy-trace perspective, therefore, verbatim traces were predominant in younger adults, but gist traces were predominant in AD patients. For older adults, these counteracting influences of verbatim and gist may have led to the observed pattern, which was intermediate between that of the AD patients and younger adults.

By comparing gist-based and source-based influences on false memories, we have examined the types of factors that likely give rise to false remembering in real world settings (see also Budson et al., 2004). False memories often occur because one misattributes the familiarity of a particular item or event to an incorrect source or context (i.e., source confusion). Such misattributions are more likely when the item or event could have plausibly occurred (i.e., is gist consistent). We suggest that examining the interplay of these two types of false recognition, particularly with regard to conditions under which such errors can be reduced, may provide additional insights into how false memories are created in various populations.

References

Balota, D. A., Cortese, M. J., Duchek, J. M., Adams, D., Roediger, H. L., McDermott, K. B., & Yerys, B. E. (1999). Veridical and false memories in healthy older adults and in dementia of the Alzheimer's type. *Cognitive Neuropsychology, 16,* 361–384.

Battig, W. F., & Montague, W. E. (1969). Category norms for verbal items in 56 categories: A replication and extension of the Connecticut category norms. *Journal of Experimental Psychology Monographs, 80*(3, Pt. 2), 1–45.

Bousfield, W. A., Whitmarsh, G. A., & Danick, J. J. (1958). Partial response entities in verbal generalization. *Psychological Reports, 4,* 703–713.

Brainerd, C. J., & Reyna, V. F. (2002). Recollection rejection: How children edit their false memories. *Developmental Psychology, 38,* 156–172.

Brainerd, C. J., Reyna, V. F., Wright, R., & Mojardin, A. H. (2003). Recollection rejection: False-memory editing in children and adults. *Psychological Review, 110,* 762–784.

Budson, A. E., Daffner, K. R., Desikan, R., & Schacter, D. L. (2000). When false recognition is unopposed by true recognition: Gist-based memory distortion in Alzheimer's disease. *Neuropsychology, 14,* 277–287.

Budson, A. E., Desikan, R., Daffner, K. R., & Schacter, D. L. (2001). Perceptual false recognition in Alzheimer's disease. *Neuropsychology, 15,* 230–243.

Budson, A. E., Michalska, K. J., Sullivan, A. L., Rentz, D. M., Dafner, K. R., & Schacter, D. L. (2003). False recognition in Alzheimer's disease. Evidence from categorized pictures. *Cognitive & Behavioral Neurology, 16,* 16–27.

Budson, A. E., Simons, J. S., Sullivan, A. L., Beier, J. S., Solomon, P. R., Scinto, L. F., et al. (2004). Memory and emotions for the September 11, 2001, terrorist attacks in patients with Alzheimer's disease, patients with mild cognitive impairment, and healthy older adults. *Neuropsychology, 18,* 315–327.

Budson, A. E., Sitarski, J., Daffner, K. R., & Schacter, D. L. (2002). False recognition of pictures versus words in Alzheimer's disease: The distinctiveness heuristic. *Neuropsychology, 16,* 163–173.

Budson, A. E., Sullivan, A. L., Daffner, K. R., & Schacter, D. L. (2003). Semantic versus phonological false recognition in aging and Alzheimer's disease. *Brain and Cognition, 51,* 251–261.

Budson, A. E., Sullivan, A. L., Mayer, E., Daffner, K. R., Black, P. M., & Schacter, D. L. (2002). Suppression of false recognition in Alzheimer's disease and in patients with frontal lobe lesions. *Brain, 125,* 2750–2765.

Dalla Barba, G., Nedjam, Z., & Dubois, B. (1999). Confabulation, executive functions, and source memory in Alzheimer's disease. *Cognitive Neuropsychology, 16,* 385–398.

Deese, J. (1959). On the prediction of occurrence of particular verbal intrusions in immediate recall. *Journal of Experimental Psychology, 58,* 17–22.

Dick, M. B., Kean, M. L., & Sands, D. (1989). Memory for action events in Alzheimer-type dementia: Further evidence of an encoding failure. *Brain and Cognition, 9,* 71–87.

Ferguson, S. A., Hashtroudi, S., & Johnson, M. K. (1992). Age differences in using source-relevant cues. *Psychology and Aging, 7,* 443–452.

Folstein, M. F., Folstein, S. E., & McHugh, P. R. (1975). A practical method for grading the cognitive state of patients for the clinician. *Journal of Psychiatric Research, 12,* 189–198.

Gallo, D. A., Sullivan, A. L., Daffner, K. R., Schacter, D. L., & Budson, A. E. (2004). Associative recognition in Alzheimer's disease: Evidence for impaired recall-to-reject. *Neuropsychology, 18,* 556–563.

Henkel, L. A., Johnson, M. K., & De Leonardis, D. M. (1998). Aging and source monitoring: Cognitive processes and neuropsychological correlates. *Journal of Experimental Psychology: General, 127,* 251–268.

Israel, L., & Schacter, D. L. (1997). Pictorial encoding reduces false recognition of semantic associates. *Psychonomic Bulletin & Review, 4,* 577–581.

Jacoby, L. L. (1991). A process dissociation framework: Separating automatic from intentional uses of memory. *Journal of Memory and Language, 30,* 513–541.

Jacoby, L. L. (1999). Ironic effects of repetition: Measuring age-related differences in memory. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 25,* 3–22.

Jacoby, L. L., Woloshyn, V., & Kelley, C. M. (1989). Becoming famous without being recognized: Unconscious influences of memory produced by dividing attention. *Journal of Experimental Psychology: General, 118,* 115–125.

Jennings, J. M., & Jacoby, L. L. (1997). An opposition procedure for detecting age-related deficits in recollection: Telling effects of repetition. *Psychology and Aging, 12,* 352–361.

Johnson, M. K., Hashtroudi, S., & Lindsay, D. S. (1993). Source monitoring. *Psychological Bulletin, 114,* 3–28.

Kensinger, E. A., & Schacter, D. L. (1999). When true memories suppress false memories: Effects of ageing. *Cognitive Neuropsychology, 16,* 399–415.

Koutstaal, W., & Schacter, D. L. (1997). Gist-based false recognition of pictures in older and younger adults. *Journal of Memory and Language, 37,* 555–583.

McIntyre, J. S., & Craik, F. I. M. (1987). Age differences in memory for item and source information. *Canadian Journal of Psychology, 41,* 175–192.

McKhann, G., Drachman, D., Folstein, M., Katzman, R., Price, D., & Stadlan, E. M. (1984). Clinical diagnosis of Alzheimer's disease: Report of the NINCDS–ADRDA work group under the auspices of Department of Health and Human Services Task Force on Alzheimer's disease. *Neurology, 34,* 939–944.

Mitchell, D. B., Hunt, R. R., & Schmitt, F. A. (1986). The generation effect and reality monitoring: Evidence from dementia and normal aging. *Journal of Gerontology, 41,* 79–84.

Mulligan, N. W., & Hirshman, E. (1997). Measuring the bases of recognition memory: An investigation of the process-dissociation framework. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 23,* 280–304.

Multhaup, K. S., & Balota, D. A. (1997). Generation effects and source memory in healthy older adults and in adults with dementia of the Alzheimer type. *Neuropsychology, 11,* 382–391.

Norman, K. A., & Schacter, D. L. (1997). False recognition in younger and older adults: Exploring the characteristics of illusory memories. *Memory & Cognition, 25,* 838–848.

Reyna, V. F., & Brainerd, C. J. (1995). Fuzzy-trace theory: An interim synthesis. *Learning and Individual Differences, 7,* 1–75.

Roediger, H. L., III, & McDermott, K. B. (1995). Creating false memories: Remembering words not presented in lists. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 21,* 803–814.

Schacter, D. L. (1996). *Searching for memory: The brain, the mind, and the past.* New York: Basic Books.

Schacter, D. L. (1999). The seven sins of memory: Insights from psychology and cognitive neuroscience. *American Psychologist, 54,* 182–203.

Schacter, D. L. (2001). *The seven sins of memory: How the mind forgets and remembers.* New York: Houghton Mifflin.

Schacter, D. L., Israel, L., & Racine, C. (1999). Suppressing false recognition in younger and older adults: The distinctiveness heuristic. *Journal of Memory and Language, 40,* 1–24.

Schacter, D. L., Kaszniak, A. W., Kihlstrom, J. F., & Valdiserri, M. (1991). The relation between source memory and aging. *Psychology and Aging, 6,* 559–568.

Schacter, D. L., Koutstaal, W., Johnson, M. K., Gross, M. S., & Angell, K. E. (1997). False recollection induced by photographs: A comparison of older and younger adults. *Psychology and Aging, 12,* 203–215.

Schacter, D. L., Verfaellie, M., Anes, M. D., & Racine, C. (1998). When true recognition suppresses false recognition: Evidence from amnesic patients. *Journal of Cognitive Neuroscience, 10,* 668–679.

Smith, J. A., & Knight, R. G. (2002). Memory processing in Alzheimer's disease. *Neuropsychologia, 40,* 666–682.

Smith, S. M., Tindell, D. R., Pierce, B. H., Gilliland, T. R., & Gerkens, D. R. (2001). The use of source memory to identify one's own episodic confusion errors. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 27,* 362–374.

Smith, S. M., Ward, T. B., Tindell, D. R., Sifonis, C. M., & Wilkenfeld, M. J. (2000). Category structure and created memories. *Memory & Cognition, 28,* 386–395.

Spencer, W. D., & Raz, N. (1995). Differential effects of aging on memory for content and context: A meta-analysis. *Psychology and Aging, 10,* 527–539.

Tendolkar, I., Schoenfeld, A., Golz, G., Fernandez, G., Kühl, K.-P., Ferszt, R., & Heinze, H.-J. (1999). Neural correlates of recognition memory with and without recollection in patients with Alzheimer's disease and healthy controls. *Neuroscience Letters, 263,* 45–48.

Trott, C. T., Friedman, D., Ritter, W., Fabiani, M., & Snodgrass, J. G. (1999). Episodic priming and memory for temporal source: Event-related potentials reveal age-related differences in prefrontal functioning. *Psychology and Aging, 14,* 390–413.

Tun, P. A., Wingfield, A., Rosen, M. J., & Blanchard, L. (1998). Response latencies for false memories: Gist-based processes in normal aging. *Psychology and Aging, 13,* 230–241.

Underwood, B. J. (1965). False recognition produced by implicit verbal responses. *Journal of Experimental Psychology, 70,* 122–129.

Received March 24, 2004
Revision received June 14, 2004
Accepted June 15, 2004 ■