Effects of Distinctive Encoding on Source-based False Recognition

Further Examination of Recall-to-Reject Processes in Aging and Alzheimer Disease

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Objective: To examine the use of distinctive materials at encoding on recall-to-reject monitoring processes in aging and Alzheimer disease (AD).

Background: AD patients, and to a lesser extent older adults, have shown an impaired ability to use recollection-based monitoring processes (eg, recall-to-reject) to avoid various types of false memories, such as source-based false recognition.

Method: Younger adults, healthy older adults, and AD patients engaged in an incidental learning task, in which critical category exemplars were either accompanied by a distinctive picture or were presented as only words. Later, participants studied a series of categorized lists in which several typical exemplars were omitted and were then given a source memory test.

Results: Both older and younger adults made more accurate source attributions after picture encoding compared with word-only encoding, whereas AD patients did not exhibit this distinctiveness effect.

Conclusions: These results extend those of previous studies showing that monitoring in older adults can be enhanced with distinctive encoding, and suggest that such monitoring processes in AD patients many be insensitive to distinctiveness.

Key Words: false memory, recall-to-reject, distinctiveness, aging, Alzheimer disease

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Memory is not a perfect record of the past, but is instead a constructive process that is subject to various kinds of errors and distortions.[1–4] During the past decade, there has been a notable increase in the study of memory distortion in a variety of neuropsychologic patient populations, including patients with Alzheimer disease (AD) (for a review, see Ref. 5).

In addition to their inability to retrieve desired information, AD patients also suffer from distortions of memory[6] that may impair their ability to live independently.[7] The susceptibility of AD patients to various memory distortions may stem in part from deficits in recollection-based retrieval monitoring processes.[8–10] Recollection-based monitoring refers to decision processes in which retrieval of various types of information from a study episode allows one to reject an event as false.[11] Failures of retrieval monitoring may be important not only to individuals with various types of brain damage, such as AD patients, but also to healthy older adults, who likewise have shown an increased susceptibility to false memories (for a review, see Ref. 12).

One type of retrieval monitoring that has been shown to suppress false memories in younger adults is termed "recall-to-reject," in which recollecting that an item occurred in 1 source or context allows one to reject that the item occurred in another context.[11,13] A number of studies have shown that, across a variety of experimental paradigms, older adults are impaired at recall-to-reject monitoring compared with younger adults.[13–18] However, Gallo et al[19] recently showed that older adults can engage a recall-to-reject process as well as younger adults when distinctive materials (ie, pictures) were used. In the Gallo et al study, younger and older adults studied items presented as a red word, as a picture, or as both, and were then asked to decide whether test words had been studied as red words (red word test) or as pictures (picture test). When the study formats were manipulated so that items were never presented as both a red word and a picture (ie, a mutually exclusive condition), older adults reduced their source confusions relative to the nonexclusive condition, consistent with the use of a recall-to-reject monitoring process. Furthermore, older adults were as effective as younger adults at using a recall-to-reject strategy when the items to be recollected were pictures.

Recall-to-reject monitoring, which depends on retrieval of studied information to avoid false memories, can be contrasted with another type of recollection-based monitoring in which the failure to retrieve information allows one to reject a memory. For example, Israel and Schacter[20] presented 1 group of younger adults with lists of semantic associates in which each word was presented auditorily and was also accompanied by a corresponding picture. A second group heard the same words auditorily, but saw a visual presentation of the word instead of an accompanying picture. Israel and Schacter found that encoding items as pictures yielded lower false recognition of both semantically related and semantically unrelated lures than did word encoding alone, suggesting the use of a process they termed the distinctiveness heuristic.[21] According to Schacter and colleagues, the distinctiveness heuristic is a retrieval monitoring process in which expectations of recollecting distinctive information (eg, pictures) is used to avoid false recognition (for a review, see Ref. 21). Schacter et al[22] extended the use of the distinctiveness heuristic to include older adults. Schacter et al found that like young adults, older adults were able to suppress their false recognition with pictorial encoding, relative to older adults who studied semantic associates without pictures. Furthermore, in the Gallo et al[19] study discussed earlier, older adults were shown to use a distinctiveness heuristic as well as younger adults when unrelated items were used.

In the present study, we ask whether the use of distinctive information can aid AD patients in recall-to-reject monitoring. Several studies have shown that AD patients are impaired at recall-to-reject monitoring relative to controls.[10,23–25] However, these studies used various paradigms involving words, including associative recognition with word pairs,[23] word-stem completion,[24,25] and categorized word lists.[10] Therefore, it is unknown whether recall-to-reject processes in AD patients are facilitated with distinctive pictures.

There are 2 alternative predictions concerning AD patients' use of distinctive pictures in recall-to-reject monitoring. First, AD patients should benefit from encoding distinctive pictures. This prediction stems from studies that have examined AD patients' ability to use a distinctiveness heuristic. For example, Budson et al[8] examined whether AD patients could use pictures to reduce false recognition of semantic associates. Using the same paradigm as that employed by Schacter et al,[22] Budson et al found that AD patients who studied pictures were unable to reduce their false alarms compared with patients who studied words only, and in fact, showed trends toward greater false recognition. The authors argued that for the AD patients, the pictures likely enhanced memory for the gist of the semantic associates, and that this gist memory may have overwhelmed any effect of a distinctiveness heuristic. To remove the possible confound of the gist memory, Budson et al[26] employed a repetition-lag paradigm to investigate the use of a distinctiveness heuristic in AD patients. In this paradigm, participants study either a list of unrelated words or pictures and then make old-new judgments about previously studied words and new words. Importantly, new words are presented twice during the test, with a varying number of intervening words (ie, lag) between the first and second occurrence. Participants are instructed to say "old" to studied words and to say "new" to nonstudied words, even words that repeat. Thus, the use of unrelated materials removes the gist influences inherent when using lists of semantic associates. Budson et al found that AD patients were able to use a distinctiveness heuristic, although they were not able to use it on a selective basis. That is, AD patients reduced both true and false recognition after pictorial encoding compared with word encoding, possibly reflecting a shift to a more conservative response bias. Supporting the idea that patients with AD can use a distinctiveness heuristic to reduce their false recognition to some degree, Gallo et al[9] found that AD patients were able to use a distinctiveness heuristic to reduce false recognition of unfamiliar (nonstudied) lures, although they were unable to use the heuristic to reduce false recognition of familiar lures.

Therefore, the ability to use a distinctive heuristic in AD patients (albeit to a limited degree) may allow them to take advantage of pictorial information in recall-to-reject monitoring. However, to the extent that recall-to-reject reflects source-monitoring processes,[27] pictures may not boost recall-to-reject monitoring in AD patients. A number of studies have shown that the ability to recollect source information in AD patients is impaired relative to older controls.[9,10,28–33] Of particular importance, Gallo et al[9] found that AD patients were unable to make source discriminations between items presented as red words and items presented as colored line drawings, suggesting that recall-to-reject monitoring for pictures may be similarly impaired in these patients.

Our goal in the present study is to directly test recall-to-reject monitoring for distinctive pictures in AD patients and in healthy older controls and younger adults. Although Gallo et al[9] used pictorial information, their goal was to examine the use of a distinctiveness heuristic in patients rather than the use of a recall-to-reject process. We used a variant of a procedure employed by Pierce et al[10] who investigated recall-to-reject processes for words in AD patients. Pierce et al used a paradigm consisting of both deep and shallow incidental encoding tasks, followed by intentional study of a series of categorized lists in which 3 typical exemplars were omitted. Importantly, participants either deeply processed (by making sentence congruence judgments) or shallowly processed (by counting *e*s) 2 of the typical exemplars in the incidental learning phase, with the third exemplar omitted in both learning phases. In this paradigm, false recognition could be separated into 2 different types. The first type was termed "source-based false recognition," which occurs when participants correctly remember an item that was previously encountered, but misattribute the item to an incorrect source.[27]

In the Pierce et al study, mistakenly claiming that an item from the incidental phase had been presented in the categorized lists represented this type of false memory. These source-based errors can be contrasted with a second type of false recognition that likely stems from a reliance on general similarity or gist information.[34] In "gist-based false recognition," participants correctly remember the semantic gist of the studied category, but are 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. In Pierce et al's study, gist-based false recognition occurred when participants mistakenly claimed to have studied a typical category exemplar that had not been presented in either learning phase. Pierce et al found that healthy older adults were somewhat able to use source recollection from the deep processing task to avoid misattributing these items to the study lists (ie, a recall-to-reject process), but not to the extent exhibited by younger adults. In contrast, false recognition in AD patients actually increased after the deep processing task, suggesting that they were unable to use source recollection to oppose familiarity arising from incidental presentation of category exemplars.

In the present study, we used detailed color photographs in the incidental study phase to compare the ability of healthy older adults and AD patients to use distinctive information at encoding to enhance later recall-to-reject monitoring. The question we ask here is whether older adults and AD patients can use photographs of critical category exemplars (eg, apple, chair, football) to correctly reject these items from categorized lists (eg, fruit, furniture, sports), in which the critical exemplars are omitted. Correct rejection of critical category items presented as pictures will be compared with category items that are presented as only words. After Gallo et al,[19] we predict that older adults will be able to use the vivid details of photographs to boost recollection, so that recall-to-reject monitoring should be better after pictorial encoding than after word-only encoding, resulting in lower source-based false recognition. The critical question concerns the AD patients. Will their limited ability to use a distinctiveness heuristic allow them to lower source-based false recognition for pictures relative to words (ie, a recall-to-reject monitoring process) or will AD patients' deficits in recollecting source information render their recall-to-reject monitoring insensitive to the encoding of distinctive pictures? If the latter is the case, AD patients should exhibit similar levels of source-based false recognition after pictorial versus word-only encoding. In addition to using vivid color photographs, we attempted to provide additional support for recall-to-reject monitoring by changing environmental context (ie, rooms) and by using source memory tests. We also examined a group of younger adults to compare their results with those of the older controls. We predict that, like the older adults, younger adults will also be able to use distinctive pictures to boost recall-to-reject monitoring, resulting in lower source-based false recognition of pictures relative to words. In the present study, we were only concerned with examining source-based false recognition. Because we did not test category items that were never presented in either learning phase, we were unable to assess levels of gist-based false recognition, although that was not the focus of our study.

MATERIALS AND METHODS

Participants

Twenty patients with a clinical diagnosis of probable AD (based on National Institute of Neurological and Communicative Disorders and Stroke—Alzheimer Disease and Related Disorders Association criteria), McKhann et al[35] 20 healthy older adults and 20 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, and the Boston University Alzheimer Disease Center, both in Boston, MA. Healthy older adults were recruited from the Boston University Alzheimer Disease Center, 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, and through flyers posted at Harvard University and at senior centers in and around Boston. 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 (eg, Parkinson disease or Huntington disease), and brain damage from another known cause (eg, hypoxia, trauma). Written informed consent was obtained from all participants and their caregivers (where appropriate). The study was approved by the human subjects committees of Brigham and Women's Hospital, the Edith Nourse Rogers Memorial Veterans Hospital, Bedford, MA and Harvard University. Older adults and AD patients were paid $10 per hour for their participation. Younger adults were paid $10 per hour or were granted partial course credit for their participation. The patients showed mild impairment on the Mini Mental Status Examination,[36] with no one scoring below 20 (mean = 24.5, range = 20 to 28). See Table 1 for additional performance on standard neuropsychologic tests. 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 patient mean = 76.5 y, range = 66 to 84; older adults mean = 74.1 y, range = 67 to 84) and had similar levels of education (patient mean = 14.3 y, range = 9 to 24; older adults mean = 16.0 y, range = 12 to 20). The ages of the younger adults ranged from 19 to 26 years, with a mean of 21.1 years.

Materials and Design

Twelve categorized word lists (eg, Fruit, Sports) were selected and modified from the updated Battig

TABLE 1. Results of Demographics and Standard Neuropsychologic Measures in AD Patients

	Mean	SD	Minimum	Maximum
Age	76.50	5.35	66	85
Years of education	14.30	3.51	9	24
Test				
MMSE[36]	24.65	2.94	19	29
Letter fluency[37]	31.90	14.95	13	61
Category fluency[37]	25.85	11.79	7	57
Short Form Boston Naming Test (15 item)[38]				
Spontaneous	10.50	3.49	4	15
Additional with semantic cues	0.10	0.31	0	1
Additional with phonemic cues	2.10	1.97	0	7
CERAD Word List[39]				
Encoding	11.15	4.78	3	20
Recall	0.85	1.30	0	4
Recognition	5.35	2.21	2	9

AD indicates Alzheimer disease; CERAD, Consortium to Establish a Registry for Alzheimer's Disease; MMSE, Mini Mental Status Examination.

and Montague norms.[40,41] For the study lists, 2 sets of six 10-item word lists were chosen, set A and set B. For each list, 2 common category members (eg, apple and orange) were omitted and served as critical lure items. Half of 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 descending order of response frequency according to the Van Overschelde et al norms.[41] For the incidental orienting tasks, 30 filler words that were not members of any of the studied categories were chosen so that they matched the study list critical words with respect to word frequency. The filler words were divided into 2 sets of 12 words each, corresponding to sets A and B of the study lists. The remaining 6 filler items, which were not tested later, were included in both sets A and B. Along with the 18 filler words, the 2 critical lure items from each of the 6 studied categories were included, resulting in a 30-item word list for each incidental task. For the incidental task, 1 of the 2 critical items and half of the filler items were presented as both colored pictures and words. The other critical item and the other half of the filler items were presented as words only. Pictures of the items were taken from Hemera Clip Art software.

For counterbalancing purposes, participants saw each critical item and 12 of the filler items as a picture and a word half of the time and as words only the other half of the time. These 12 filler items were later tested. The remaining 6 filler items, which were not tested later, were always shown either as pictures and words or as words only.

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

Procedure

Participants were tested individually. All stimuli were presented on Apple MacIntosh computers. The experiment consisted of 3 parts that were conducted in 2 separate experimental rooms. First, participants saw a series of sentence frames in which a word was omitted and placed at the end of the sentence. Participants were instructed to judge whether the words fit the meaning of the sentence or not. The words included the 2 critical lures from each of the later studied lists, along with the 18 filler words. In the picture plus word condition, a picture of the word was shown above the sentence frame. In the word only condition, the word was also shown above the sentence frame in red letters. For each critical item and filler item that was later tested, sentence frames were created that were congruent with the item. The same sentence frames were used, regardless of whether the items were presented as pictures or as words only. For filler items that were not tested, sentence frames were created that were incongruent with the item. This resulted in a total of 24 congruent and 6 incongruent sentence/word combinations. Participants read each sentence/word frame aloud as it appeared on a computer screen and the stimuli remained until the participants gave a verbal response that the experimenter recorded on a piece of paper. The experimenter then pressed the keyboard so that the next sentence frame would appear.

After participants made judgments for all of the sentences, they moved to a different room for the second and third parts of the experiment. In the second part, participants studied 6 categorized lists in blocks of 10 items each and were told to remember the items for a later test. As in the incidental task, participants said the words aloud as they appeared on the screen. List items were presented 1 word at a time for 3 seconds each, with a 1-second interval between words. After all 10 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 48 studied target items, 12 target controls from nonstudied lists, 6 critical lures that had been presented as pictures and words in the incidental task, 6 critical lures from the incidental task that had been presented as words only, 12 false target controls or unrelated lures (the critical lures from each of 6 nonstudied lists), 6 filler items from the incidental task that had been presented as pictures and words, and 6 filler items from the incidental task that had been presented as only words. Participants were first instructed to indicate by saying "yes" or "no" whether they had seen the test word or a picture of the word somewhere in the experiment. If their response was "yes," participants were instructed to say whether the item had appeared in this room (in the lists they had just studied) or in the other room (in the sentence judgment task). Participants were told further that if the item had appeared earlier, it had been presented in only one of the rooms, not both of them. Participants were given as long as they wished to make a response. The experimenter recorded participants' responses by pressing keys on the keyboard.

RESULTS

Table 2 shows the proportion of responses to each item type that were attributed to the correct source versus the incorrect source, along with items that were missed, as a function of group (AD patients, older adults, and younger adults). The table 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). Because we were interested in examining the effect of distinctiveness on recall-to-reject monitoring processes in each individual group, we conducted a priori tests for each group individually.

Correct Source Attributions for Critical Items

The first finding of note in Table 2 is that both younger and healthy older adults were better at making correct source attributions (ie, a successful recall-to-reject process) when items had been accompanied by a picture during the incidental encoding task than when items had been presented as only words [$F(1,19) = 9.68$, $P < 0.01$, partial $\eta^2 = 0.34$ for younger adults and $F(1,19) = 15.52$, $P < 0.01$, partial $\eta^2 = 0.45$ for older adults]. This result replicates the finding that distinctiveness enhances recall-to-reject monitoring in younger and older adults.[19]

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

	Group					
	ADPatients		OlderAdults		YoungerAdults	
Item Type	M	SD	M	SD	M	SD
True targets	0.69	0.22	0.92	0.06	0.86	0.11
True target controls	0.35	0.28	0.01	0.04	0.03	0.07
True recognition (corrected)	0.33	0.22	0.90	0.06	0.83	0.14
Critical items						
Picture plus word						
Correct source	0.33	0.23	0.55	0.21	0.82	0.22
Incorrect source	0.42	0.24	0.33	0.21	0.13	0.20
Misses	0.24	0.20	0.12	0.12	0.05	0.08
Word only						
Correct source	0.27	0.20	0.38	0.22	0.69	0.21
Incorrect source	0.42	0.27	0.41	0.23	0.25	0.22
Misses	0.31	0.26	0.22	0.19	0.07	0.10
False target controls	0.48	0.31	0.03	0.06	0.04	0.08
Filler items						
Picture plus word						
Correct source	0.31	0.28	0.84	0.16	0.91	0.14
Incorrect source	0.27	0.24	0.02	0.05	0.02	0.05
Misses	0.42	0.28	0.14	0.16	0.08	0.11
Word only						
Correct source	0.29	0.22	0.72	0.24	0.72	0.24
Incorrect source	0.26	0.21	0.05	0.11	0.02	0.06
Misses	0.45	0.30	0.23	0.24	0.26	0.22

AD indicates Alzheimer disease; M, mean.

In terms of source-based false recognition, incorrect source attributions in younger adults were reduced in the picture-plus-word condition relative to the word-only condition [$F(1,19) = 6.594$, $P < 0.05$, partial $\eta^2 = 0.26$]. For older adults, incorrect source attributions were numerically lower in the picture-plus-word condition compared with the word-only condition, although this difference was not significant [$F(1,19) = 2.45$, $P = 0.13$]. It should be noted that older adults' higher level of missed items in the word-only condition ($M = 0.22$) compared with when the items had been accompanied by a picture ($M = 0.12$) likely contributed to the lack of a significant difference in incorrect source attributions.

For AD patients, there was no effect of picture encoding on correct source attributions [$F(1,19) = 1.31$, $P = 0.27$]. Furthermore, incorrect source attributions (ie, source-based false recognition) were identical in the picture-plus-word and the word-only conditions ($M = 0.42$). Clearly, AD patients' recall-to-reject monitoring is not enhanced through distinctive encoding.

Correct Source Attributions for Filler Items

We also analyzed correct source attributions for those incidentally presented items that were unrelated to any of the categories that participants later studied. When these filler items were accompanied by a picture during the incidental task, older adults' correct source attributions were greater than when the items were presented as only words [$F(1,19) = 6.00$, $P < 0.05$, partial $\eta^2 = 0.24$]. Younger adults were also able to use the pictures to make more accurate source attributions for these items [$F(1,19) = 10.72$, $P < 0.01$, partial $\eta^2 = 0.36$]. As was the case with the critical items, however, AD patients were unable to use the pictures to correctly reject these items at test [$F(1,19) < 1$]. It should be noted that AD patients' correct source attributions for the filler items were no better than chance, regardless of whether the items had been presented as pictures or only words.

True Recognition: True Targets Minus True Target Controls

A final analysis examined corrected true recognition for the categorized list items studied in phase 2. True recognition was measured as participants' "yes" responses to these items, regardless of which source the items were attributed to. As Table 2 shows, AD patients demonstrated significantly lower levels of corrected true recognition than did older adults [$F(1,38) = 127.16$, $P < 0.001$, partial $\eta^2 = 0.77$]. Interestingly, older adults exhibited higher true recognition than did younger adults [$F(1,38) = 5.12$, $P < 0.05$, partial $\eta^2 = 0.12$].

DISCUSSION

The present study examined the ability of younger adults, healthy older adults, and mild AD patients to use distinctive pictorial information at encoding to later suppress source-based false recognition, which involved using a recall-to-reject monitoring process. We showed that, whereas younger adults and older controls enhanced their recall-to-reject ability by studying pictures relative to studying only words, mild AD patients did not. This impaired monitoring in mild AD patients was demonstrated, not only for critical items that were typical members of various categories, but also for filler items that were unrelated to studied categories. Whereas older adults have shown to be impaired on a number of tasks that require recall-to-reject,[14–18] they have shown enhanced recall-to-reject monitoring when distinctive pictures are used.[19] The present study provides additional evidence that distinctiveness improves such monitoring in older adults. It is of note that the older adults in this study demonstrated rather poor source memory for incidentally presented items, despite showing better true target recognition than younger adults, although their source recollection was enhanced after distinctive picture encoding. This suggests that source-monitoring difficulties among older adults may be alleviated to some extent by manipulations that increase the distinctiveness of the encoded event. It is also worth noting that the present results confirm the speculation of Gallo et al[19] concerning the failure of Gallo et al[15] to find an enhancement effect of pictures on recall-to-reject monitoring in older adults. In the Gallo et al[15] study, pictures were included in both Deese-Roediger-McDermott lists and an exclusion list (referred to as a "helper list"). Gallo et al[19] proposed that older adults' monitoring of distinctive information was made more difficult in this list-discrimination task, and that older adults can use distinctive pictures to lower false recognition if the pictures are presented in 1 source, thereby making source monitoring (i.e., recall-to-reject) better. Our study directly tests the Gallo et al[19] hypothesis and confirms it: older adults recall-to-reject monitoring is enhanced when distinctive information is presented in only 1 source.

For AD patients, the use of distinctive information to reduce false recognition has only been shown under certain conditions[9,26] and only when monitoring was diagnostic in nature. That is, false recognition reduction in AD patients has only been shown by their limited (ie, nonselective) use of a distinctiveness heuristic,[22] in which the absence of memory for distinctive details of studied items (eg, pictures) is diagnostic that such items were not presented. In contrast, false recognition reduction in the present study required participants to recall that distinctive items were presented, which represents a recall-to-reject process. AD patients were unable to successfully engage in this type of monitoring.

The failure of AD patients to use distinctive picture information to reduce source-based false recognition extends the results of previous studies that have shown that recall-to-reject monitoring is impaired in mild-to-moderate AD. As noted in the introduction, Gallo et al[23] provided evidence of impaired recall-to-reject in AD patients using an associative recognition task. In this task, patients and age-matched controls studied a series of word pairs (eg, kite-river, fire-flute), with some pairs presented once and some 3 times. At test, participants were presented with intact pairs (eg, kite-river), rearranged pairs (eg, kite-flute), and new nonstudied pairs. Results showed that repetition of studied pairs increased false alarms to rearranged pairs in AD patients, but not in controls. Presumably, controls could counteract the increased familiarity resulting from repetition by retrieving associative information corresponding to these pairs, thereby allowing controls to recall that the words had been studied in different pairs. Recollection of associative information was impaired in AD patients, rendering them more susceptible to familiarity-based false alarms of the rearranged pairs. Likewise, in the present study, retrieval of distinctive picture information from the incidental learning task allowed older controls to reduce their source-based false recognition relative to the condition in which only words were incidentally presented. Therefore, encoding distinctive stimuli improved recall-to-reject monitoring in older controls, but not in AD patients.

We note that our results are compatible, not only with the source-monitoring framework,[27] but also with fuzzy-trace theory.[42,43] Fuzzy-trace theory posits that events are encoded in both verbatim traces that encompass the surface form of perceived experiences, including source or contextual information, and gist traces that represent the general meaning or pattern that results from encoding these surface forms. Subsequent false memories occur when verbatim traces are too weak to oppose the gist of the experienced event. The ability to retrieve verbatim traces, therefore, allows one to reject nonpresented lures that represent only gist traces, a process that Brainerd et al[43] termed "recollection rejection," which is a process analogous to recall-to-reject monitoring. In the present study, distinctive picture information may have strengthened verbatim traces in younger adults and older controls, allowing them to reject these lures at test. For AD patients, verbatim processing may indeed have been greater for pictures relative to words, but patients' impaired verbatim memory may have prevented them from using recollection rejection at test. Alternatively, the presentation of pictures and words during the incidental task may have served to offset to some extent the semantic processing impairments shown by AD patients on some tasks.[44] Consequently, the sentence judgment task may have helped AD patients to connect meaning when later studying the categorized lists, thereby strengthening false memory responses to both pictures and words.

We do not suggest that false recognition suppression in the present study was due entirely to a recall-to-reject monitoring process (or recollection rejection). For the filler items that were presented in the incidental task, but were unrelated to the categories that participants later studied, other retrieval-monitoring processes may have been at work. For example, when encountering a filler item (eg, clock) at test, participants may have been able to reject the item because it was unrelated to any of the categories they had just studied. Indeed, younger adults and older controls made few incorrect source attributions to such items, although these errors were greater when the filler items had been presented as only words. In contrast, AD patients made substantial source misattributions to these items, even when the items had been studied with distinctive pictures. The design of the present study did not allow us to distinguish between these different monitoring processes.

In conclusion, this study provides additional evidence that distinctiveness can enhance recollection-based monitoring processes in healthy older adults, but that distinctiveness may have little effect on these processes in AD patients. In particular, our results suggest that whereas AD patients can exhibit a limited, nonspecific use of the distinctiveness heuristic to avoid some types of false recognition,[9,26] they are unable to use distinctive information, at least when it is incidentally presented, to avoid false recognition when a recall-to-reject monitoring process is required. Although it remains to be seen whether any combination of distinctive stimuli and instructional manipulations may help AD patients reduce their source-based false recognition, the present study further supports the idea that impaired monitoring is an important factor underlying memory distortion in AD.

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REFERENCES

1. Loftus EF. Planting misinformation in the human mind: a 30-year investigation of the malleability of memory. *Learn Mem*. 2005; 12:361–366.
2. Roediger HL III, McDermott KB. Tricks of memory. *Curr Dir Psychol Sci*. 2000;9:123–127.
3. Schacter DL. The seven sins of memory: insights from psychology and cognitive neuroscience. *Am Psychol*. 1999;54:182–203.
4. Schacter DL. *The Seven Sins of Memory: How the Mind Forgets and Remembers*. Boston and New York: Houghton-Mifflin; 2001.
5. Schacter DL, Slotnik SD. The cognitive neuroscience of memory distortion. *Neuron*. 2004;44:149–160.
6. Förstl H, Besthorn C, Burns A, et al. Delusional misidentification in Alzheimer's disease: a summary of clinical and biological aspects. *Psychopathology*. 1994;27:194–199.
7. Borson S, Raskind MA. Clinical features and pharmacologic treatment of behavioral symptoms of Alzheimer's disease. *Neurology*. 1997;48:S17–S24.
8. Budson AE, Sitarski J, Daffner KR, et al. False recognition of pictures versus words in Alzheimer's disease: the distinctiveness heuristic. *Neuropsychology*. 2002;16:163–173.
9. Gallo DA, Chen JM, Wiseman AL, et al. Retrieval monitoring and anosognosia in Alzheimer's disease. *Neuropsychology*. 2007;21: 559–568.
10. Pierce BH, Sullivan AL, Schacter DL, et al. Comparing source-based and gist-based false recognition in aging and Alzheimer's Disease. *Neuropsychology*. 2005;18:411–419.
11. Gallo DA. *Associative Illusions of Memory: False Memory Research in DRM and Related Tasks*. New York: Psychology Press; 2006.
12. Pierce BH, Simons JS, Schacter DL. Aging and the seven sins of memory. In: Costa P, ed. *Advances in Cell Aging and Gerontology*. Vol. 15. Amsterdam: Elsevier; 2004:1–40.
13. Jacoby LL. Ironic effects of repetition: measuring age-related differences in memory. *J Exp Psychol Learn Mem Cogn*. 1999;25: 3–22.
14. Castel AD, Craik FIM. The effects of aging and divided attention on memory for item and associative information. *Psychol Aging*. 2003; 18:873–885.
15. Gallo DA, Bell DB, Beier JS, et al. Two types of recollection-based monitoring in younger and older adults: recall-to-reject and the distinctiveness heuristic. *Memory*. 2006;14:730–741.
16. Jennings JM, Jacoby LL. An opposition procedure for detecting age-related deficits in recollection: telling effects of repetition. *Psychol Aging*. 1997;12:352–361.
17. Jones TC, Jacoby LL. Conjunction errors in recognition memory: modality-free errors for older adults but not for younger adults. *Acta Psychol (Amst)*. 2005;120:55–73.
18. Multhaup KS. Aging, source, and decision criteria: when false fame errors do and do not occur. *Psychol Aging*. 1995;10: 492–497.
19. Gallo DA, Cotel SC, Moore CD, et al. Aging can spare recollection-based retrieval monitoring: the importance of event distinctiveness. *Psychol Aging*. 2007;22:209–213.
20. Israel L, Schacter DL. Pictorial encoding reduces false recognition of semantic associates. *Psychon Bull Rev*. 1997;4:577–581.
21. Schacter DL, Wiseman AL. Reducing memory errors: the distinctiveness heuristic. In: Hunt RR, Worthen J, eds. *Distinctiveness and Memory*. New York: Oxford University Press; 2006:89–107.
22. Schacter DL, Israel L, Racine C. Suppressing false recognition in younger and older adults: the distinctiveness heuristic. *J Mem Lang*. 1999;40:1–24.
23. Gallo DA, Sullivan AL, Daffner KR, et al. Associative recognition in Alzheimer's disease: evidence for impaired recall-to-reject. *Neuropsychology*. 2004;18:556–563.
24. Knight RG. Controlled and automatic memory processes in Alzheimer's disease. *Cortex*. 1998;34:427–435.
25. Koivisto M, Portin R, Seinela A, et al. Automatic influences of memory in Alzheimer's disease. *Cortex*. 1998;34:427–435.
26. Budson AE, Dodson CS, Daffner KR, et al. Metacognition and false recognition in Alzheimer's disease: further exploration of the distinctiveness heuristic. *Neuropsychology*. 2005;19:253–258.
27. Johnson MK, Hashtroudi S, Lindsay DS. Source monitoring. *Psychol Bull*. 1993;114:3–28.
28. Dalla Barba G, Nedjam Z, DuBois B. Confabulation, executive functions, and source memory in Alzheimer's disease. *Cognit Neuropsychol*. 1999;16:385–398.
29. Dick MB, Kean ML, Sands D. Memory for action events in Alzheimer-type dementia: further evidence of an encoding failure. *Brain Cogn*. 1989;9:71–87.
30. Mitchell DB, Hunt RR, Schmitt FA. The generation effect and reality monitoring: evidence from dementia and normal aging. *J Gerontol*. 1986;41:79–84.
31. Multhaup KS, Balota DA. Generation effects and source memory in healthy older adults and in adults with dementia of the Alzheimer type. *Neuropsychology*. 1997;11:382–391.
32. Smith JA, Knight RG. Memory processing in Alzheimer's disease. *Neuropsychologia*. 2002;40:666–682.
33. Tendolkar I, Schoenfield A, Golz G, et al. Neural correlates of recognition memory with and without recollection in patients with Alzheimer's disease and healthy controls. *Neurosci Lett*. 1999; 263:45–48.
34. Brainerd CJ, Reyna VF. Fuzzy-trace theory and children's false memories. *J Exp Child Psychol*. 1998;71:81–129.
35. McKhann G, Drachman D, Folstein M, et al. 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*. 1984; 34:939–944.
36. Folstein MF, Folstein SE, McHugh PR. A practical method for grading the cognitive state of patients for the clinician. *J Psychiatric Res*. 1975;12:189–198.
37. Monsch AU, Bondi MW, Butters N, et al. Comparisons of verbal fluency tasks in the detection of dementia of the Alzheimer type. *Arch Neurol*. 1992;49:1253–1258.

38. Fastenau PS, Denburg NL, Mauer BA. Parallel short forms for the Boston Naming Test: psychometric properties and norms for older adults. *J Clin Exp Neuropsychol*. 1998;20:828–834.
39. Morris JC, Heyman A, Mohs RC, et al. The Consortium to Establish a Registry for Alzheimer's Disease (CERAD). Part I. Clinical and neuropsychological assessment of Alzheimer's disease. *Neurology*. 1989;39:1159–1165.
40. Battig WF, Montague WE. Category norms for verbal items in 56 categories: a replication and extension of the Connecticut category norms. *J Exp Psychol Monogr*. 1969;80:1–45.
41. Van Overschelde JP, Rawson KA, Dunlosky J. Category norms: an updated and expanded version of the Battig and Montague (1969) norms. *J Mem Lang*. 2004;50:289–335.
42. Brainerd CJ, Reyna VF. Recollection rejection: how children edit their false memories. *Dev Psychol*. 2002;38:156–172.
43. Brainerd CJ, Reyna VF, Wright R, et al. Recollection rejection: false-memory editing in children and adults. *Psychol Rev*. 2003; 110:762–784.
44. Budson AE, Sullivan AL, Daffner KR, et al. Semantic and phonological false recognition in aging and Alzheimer's disease. *Brain Cogn*. 2003;51:251–261.

