*Original Article*

# False Recognition in Alzheimer Disease: Evidence from Categorized Pictures

*†Andrew E. Budson, MD, *Kalina J. Michalska, BS, *Alison L. Sullivan, BA,
*†Dorene M. Rentz, PsyD, *†Kirk R. Daffner, MD, and ‡Daniel L. Schacter, PhD

## Abstract

**Objectives:**
To better understand memory distortions and false recognition in patients with Alzheimer disease (AD), using a paradigm of categorized color photographs.

**Background:**
Previous research has found that patients with AD and older adults showed similar levels of uncorrected false recognition of semantic associates and of perceptually related novel objects. In contrast to these results, using a paradigm in which semantically related words were accompanied by black and white line drawings, it was found that patients with AD showed a trend toward higher levels of uncorrected false recognition compared with older adults.

**Methods:**
To explore this trend, 24 patients with AD and 24 older adults matched for age, education, and gender were examined using a false recognition paradigm consisting of categorized color photographs (e.g., flowers, motorcycles, cats).

**Results:**
Compared with older adults, patients with AD showed higher levels of uncorrected false recognition, but lower levels of corrected false recognition and lower levels of item-specific recollection.

**Conclusions:**
The authors suggest that these results may be attributable to the poor ability of patients with AD to acquire both gist and item-specific information as well as these patients' inherent frontal lobe dysfunction leading to difficulty inhibiting responses on the basis of familiarity alone.

**Key Words:** False recognition, Memory, Memory distortions, Neurodegenerative disease, Photographs

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Patients with probable Alzheimer disease (AD) exhibit distortions of memory in addition to their difficulty in retrieving desired information (1). Sometimes these distortions are extreme, as is the case in syndromes of delusional misidentification such as Capgras syndrome and reduplicative paramnesia (1,2). More commonly, however, these memory distortions are mundane, although still important clinically. For example, patients may not turn off the stove or take their medications because they erroneously remember having performed these activities. Memory distortions may thus prevent the patient with AD from living independently (3).

Much of the previous work on memory distortions in patients with AD has focused on intrusions—the production of unstudied items during recall on memory tests. For example, Fuld et al. (4) found that intrusions are common in patients with AD and that they correlate with low levels of choline acetyltransferase and high numbers of senile plaques in the cerebral cortex.

Memory distortions in AD have been examined using paradigms that allow measurement not only of recall intrusions but also of a similar type of memory distortion known as *false recognition*. False recognition occurs when people incorrectly claim to have previously encountered a novel item that is in some way related to a studied item. False recognition has been studied more extensively and analytically than have recall intrusions (5), and therefore may allow insights into memory distortion in patients with AD that would be difficult to obtain from studies of intrusion errors. Experiments originally performed by Deese (6), and revived and modified by Roediger and McDermott (7), have demonstrated robust levels of false recognition in healthy adults. After studying lists

of semantic associates (e.g., *candy, sour, sugar, bitter, good, taste,* and so forth) that all converge on a nonpresented theme word or related lure (e.g., *sweet*), participants frequently intruded the related lure on free recall tests (6), and made very high levels of false alarms to these words on recognition tests (7).

Using the Deese/Roediger-McDermott (DRM) paradigm, patients with AD have been found to show similar rates of false recall of semantic (8,9) and phonologic (9) associates compared with older adults. In addition, Balota et al. (8) found that patients with very mild AD falsely recognized similar numbers of related lures compared with older adults, whereas patients with mild AD falsely recognized fewer related lures. Both very mild and mild patients with AD showed lower levels of false recognition compared with older adults after correction for false alarms to unrelated items.

Following the work of Kensinger and Schacter (10) with younger and older adults, and Schacter et al. (11) involving patients with amnesia, Budson et al. (12) examined patients with AD, older adults, and younger adults with a paradigm that provided rates of false recognition after single and multiple exposures to word lists. After correction for false alarms to unrelated items, Budson et al. (12) found that compared with healthy older adults, patients with AD showed lower levels of false recognition after a single exposure to semantic associates, but higher levels of false recognition after five study-test trials. Budson et al. (12) interpreted their results based upon the idea that true and false recognition depend on memory for two different kinds of information: specific details of a prior encounter with a particular item (item-specific recollection) and the general meaning, idea, or gist conveyed by a collection of items [gist information (5,13)]. As the items are presented in the DRM paradigm, a gist representation is developed, which may result in an experience of recollection or familiarity when either a studied item or a related lure is presented on a later recognition test. Thus, in the DRM paradigm, accurate recognition of previously studied items probably depends on both item-specific and gist information, whereas false recognition of related lure words depends on remembering gist but not item-specific information (14–16). The lower level of corrected false recognition seen in the initial trial for patients with AD compared with older adults suggests that these patients were initially less sensitive to gist influences than were healthy older adults. The steady increase in false recognition over the five trials shown by patients with AD suggests that the repeated study and testing of semantic associates creates an increasingly robust representation of semantic gist that, when unchecked by item-specific recollection, produces increasingly elevated levels of false recognition [see Schacter et al. (11) for similar findings and ideas concerning Korsakoff amnesic patients]. Young adults showed a steady decrease in false recognition across trials, suggesting that they were able to use increased item-specific recollection to reduce (or suppress) false recognition over the study-test trials. Older adults exhibited an intermediate pattern: unchanging false recognition over the first three trials, and some evidence of suppression on the final two trials, suggesting the development of a small degree of item-specific recollection [c.f. Kensinger and Schacter (10)].

Budson et al. (17) extended these ideas to the perceptual domain by examining false recognition of perceptually related novel objects in patients with AD and healthy older adults. In this paradigm, the gist developed by participants is perceptually rather than semantically based. Nonetheless, as with semantically associated words after a single study-test trial (8,12), patients with AD showed lower levels of false recognition of perceptually related novel objects compared with older adults after correction for unrelated false alarms. Budson et al. (17) speculated that, as in the case of semantically associated words, patients with AD exhibited lower levels of corrected false recognition of perceptually related novel objects because

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their gist memory for these perceptually related items is impaired relative to healthy older adults.

Applying a paradigm used previously with younger (18) and older adults (19), Budson et al. (20) examined false recognition of semantic associates accompanied by pictures (black and white line drawings) representing each associate in patients with AD and older adults. One interesting aspect of these data is that there was a numerical trend for patients with AD who studied and were tested with pictures to show greater uncorrected false recognition compared with older adults, 0.67 versus 0.45, respectively, $F(1,16) = 3.46$, $p = 0.081$. Such a trend was not observed between patients with AD and older adults in either the semantic [0.66 versus 0.69 (12)] or perceptual (0.61 versus 0.60, large categories, Table 2 (17)] paradigms. Why patients with AD should show relatively greater false recognition compared with older adults for these black and white drawings versus either semantically related words or perceptually related novel objects is unclear.

Budson et al. (20) suggested that whereas older adults were able to use the distinctive information of the studied pictures to reduce their false recognition for new pictures, this information may have served only to enhance the gist memory of patients with AD, increasing their false recognition. There is, however, another explanation, which is related to the fact that the pictures used in Budson et al. (20) were line drawings. Patients with AD are known to show deficits in their ability to correctly identify and perceive line drawings (21,22). Cormier et al. (21) showed that patients with AD were impaired in their naming of line drawings compared with controls, and that they made more perceptual than semantic errors. Stevens (22) found that patients with AD made almost twice as many errors when naming black and white line drawings than when naming color photographs. Lastly, Montanes et al. (23) found that patients with AD appeared to show a category-specific defi-

cit affecting the knowledge of living things when tested with black and white line drawings; this category-specific deficit disappeared, however, when participants underwent a similar study with colored pictures. Thus, the patients with AD who studied pictures in Budson et al. (20) may have demonstrated high levels of false recognition simply because their impairment in accurately perceiving the black and white line drawings made it difficult for them to distinguish between studied and nonstudied items.

In the current study we wanted to further explore the false recognition of pictures in patients with AD. First, we wanted to ascertain whether the trend observed for patients with AD, compared with older adults, to show greater uncorrected false recognition of black and white line drawings (20) would be strengthened or weakened when an experimental paradigm consisting of colored photographs was used. We presumed that the rich detail of colored photographs would minimize effects of the patients' perceptual impairment, as in the previous studies (22,23). Thus, we would not attribute the results of the previous study using black and white line drawings (20) to perceptual difficulties if patients with AD showed greater uncorrected false recognition of these colored photographs as well.

Second, we were interested in determining whether patients with AD would show impairment relative to older adults in their gist memory of these categorized color photographs. Categorized items are different from items that are semantically related to a lure word or perceptually related to a category prototype. Whereas in the latter two cases a gist representation is built up that converges on a single item, with categorized items a gist representation of the entire category is developed. Patients with AD may demonstrate less impairment in forming a more diffuse gist representation of an entire category than a specific gist representation of a lure word or prototype. Thus, if patients with AD and older adults show similar levels

of corrected false recognition, we would conclude that patients with AD do not show impairment in formation and memory for this "category gist." If, on the other hand, patients with AD show lower levels of corrected false recognition compared with older adults, we would conclude that patients with AD are impaired in their gist memory for categories as well as for lure words and prototypes.

Third, we also wanted to investigate item-specific recollection in AD using these categorized color photographs. Previous work in younger and older adults using these photographs (24) has demonstrated that participants are able to develop high levels of item-specific recollection, presumably due to the rich details provided by the photographs. Because patients with AD have demonstrated very little item-specific recollection in previous studies (12,17), we were interested to see whether patients with AD would show high levels of item-specific recollection with these stimuli.

We have included a manipulation of category size in the current study so as to maximize the development of both gist memory and item-specific recollection. Large categories with 18 items presented at study allow for maximum development of gist and may bring out a gist deficit not seen in smaller categories, as occurred in a previous study (17). Small categories with three items presented at study provide the opportunity for the development of greater item-specific recollection because there are fewer items for participants to remember the specific details of. Note that although we have included this manipulation of category size to maximize gist memory and item-specific recollection, the ability to detect between-group differences in these components of memory depends upon finding main effects, not interactions. True recognition can be thought of as a combination of gist memory plus item-specific recollection, whereas false recognition is likely a measure of gist memory minus any item-specific recollection that is available to counteract the effect of gist. Thus, a rough estimate of gist memory may be provided by false recognition, and a measure of item-specific recollection may be calculated by subtracting false recognition from true recognition.

## MATERIALS AND METHODS

### Participants

Twenty-four patients with a clinical diagnosis of probable AD [National Institute of Neurological and Communicative Disorders and Stroke-Alzheimer's Disease and Related Disorders Association criteria used (25)] and 24 healthy older adults were recruited for the experiment. Patients with AD were recruited from the clinical population at the Memory Disorders Unit, Brigham and Women's Hospital, Boston, Massachusetts, USA. Older adults were recruited from participants in a longitudinal study of normal aging at Brigham and Women's Hospital, from spouses and friends of the patients with AD, as well as from flyers and posters placed in senior centers in and around Boston. Written informed consent was obtained from all participants and their caregivers (where appropriate). The study was approved by the human subjects committee of Brigham and Women's Hospital. Participants were paid $10/h for their participation. Older adults were all community dwelling and were excluded if they scored less than 27 on the Mini-Mental Status Examination [MMSE (26)]. Most patients with AD showed mild to moderate impairment on the MMSE (mean = 22.0, range 14–27). Participants were excluded if they were characterized by clinically significant depression, alcohol or drug use, cerebrovascular disease, traumatic brain damage, or if English was not their primary language. All participants had normal or corrected to normal vision. The patients with AD were matched to the older adults on the basis of sex (10 male and 14 female participants in each group), age (patients with AD mean = 74.6 years, range 59–86 years; older adult mean 74.4 years, range 60–89 years), and education (patients with

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AD mean 16.0 years, range 10–20 years; older adult mean 15.8 years, range 12–20 years).

## Design

The experimental design included a between-subjects factor of group (patients with AD versus older adults) and a within-subjects factor of category size. For studied items, category size had 2 levels: 3 and 18 category exemplars presented, termed small and large categories respectively. Nonstudied items had three levels of category size—the aforementioned two levels plus "novel" category items for which no related items were present at study; the novel items provided an estimate of baseline levels of false alarms. Studied and nonstudied unrelated items were also used to increase the variety of pictures presented as well as to provide a measure of participant performance on a more standard memory test.

## Stimuli

The stimuli were identical to those used in Koutstaal et al. (27) and consisted of colored photographs of single objects (or, in a few cases, coherent grouping of objects), without background, taken from various illustrated books for children and adults. All pictures were initially mounted on white index cards and then were scanned and converted to digital format using VistaScan and a UMAX Vista-S6E scanner (UMAX Technologies, Inc., Fremont, CA, USA). At both study and test, the pictures were displayed in the center of a color computer monitor using an Apple Macintosh Powerbook 5300c computer and PsyScope software (28).

The pictures portrayed objects from 25 different object categories, with each category comprising a total of 21 different exemplars. For example, there were 21 pictures of birds. The categories were randomly assigned to 6 sets of 4 categories each (1 of the 25 categories, chosen randomly, was not used), and each set was rotated through the experimental conditions such that each set equally often served as a study category comprising 3 or 18 related items or as a novel, nonstudied item. When a given category served as a large (18-exemplar) category, all but 3 of the items were presented at study; the remaining 3 items were reserved to be presented during the recognition test as new but related lure items. Likewise, when a given category served as a small (three-exemplar) category, only a subset of the total pool of items was presented at study. In the latter cases, the particular items excluded were determined randomly, with the same items always excluded whenever that small category was presented.

As in previous experiments of this type (27,24), each studied category was tested an equal number of times: three times with a studied item and three times with a lure item, to avoid confounding the number of items per category that were presented at study with the number of items that were presented at test. This was accomplished by selecting a subset of items from each category, which always served as the critical study and test items. For each category, six items were randomly selected to serve as the critical target and lure items. These items were then assigned to two subsets and were rotated through the study and test lists such that each subset equally often served as targets and lures for the studied categories, or as novel items for the nonstudied categories. The novel categories were also tested three times.

For the unrelated items, 24 of the total 30 items were chosen randomly to be used in the experiment. These were divided into 2 sets (X and Y) of 12 unrelated items each. Half of the participants were shown set X during the study session; the other half were shown set Y. Both sets were presented during the test session, scored appropriately as either studied or nonstudied unrelated items. Counterbalancing required 24 participants.

Each study list comprised a total of 102 items: items from 4 large categories (4 × 18), 4 small categories (4 × 3), 12 unrelated items (12 × 1), 3 primacy and 3 recency buffers. Each test list comprised a total of 84 items: 3 studied and 3 lure items from each of the

large and small categories (4 categories × 6 items/category × 2 category sizes), 3 novel items each from 4 nonstudied categories (3 × 4), and 12 studied and 12 nonstudied unrelated items (12 × 2).

## Procedure

The overall procedure involved three phases: a study phase, a brief retention interval, and a test phase. All participants were tested individually, either in their homes or at Brigham and Women's Hospital, Boston, Massachusetts, USA.

In the study phase, participants were presented with each item for 2 seconds, and were asked to rate their liking ("like" or "dislike") for each of them. Although each picture disappeared after 2 seconds, the liking rating was self-paced. The pictures from different categories were randomly intermixed (not blocked as in a typical DRM paradigm), and the encoding task was incidental; no mention was made of a subsequent memory test. Participants stated their liking rating orally and the experimenter then entered the appropriate response on the keyboard.

During the brief retention interval, participants performed simple puzzles for 5 minutes.

In the test phase, participants were given a surprise recognition test as described herein and were asked to designate each item as "old" (previously presented during the study phase) or "new" (not previously presented during the experiment). After the test phase, which was self-paced, participants were debriefed.

## RESULTS

Table 1 presents the proportion of "old" responses to studied items (true recognition) and to nonstudied items (false recognition) as a function of category size (large and small) and group (patients with AD and older adults). Also shown in Table 1 is the proportion of "old" responses to studied and nonstudied unrelated items, and to novel items—nonstudied categorized items for which no categorically related items were presented at study. The unrelated items provide one measure of true recognition and false alarms, whereas the novel items provide an index of the baseline false alarm rate.

## Unrelated Items

A one-way analysis of variance (ANOVA) showed that patients with AD made fewer "old" responses to studied unrelated items ($F(1,46) = 39.09$, $p < 0.0005$), more false alarms to nonstudied unrelated items ($F(1,46) = 17.92$, $p < 0.0005$), and consequently, they showed a lower corrected hit rate ($F(1,46) = 73.32$, $p < 0.0005$) compared with healthy older adults (Table 1).

## Novel Items (Baseline False Alarms)

Compared with healthy older adults, patients with AD made significantly more false alarms to nonstudied novel items for

**TABLE 1.** True and false recognition responses by category size

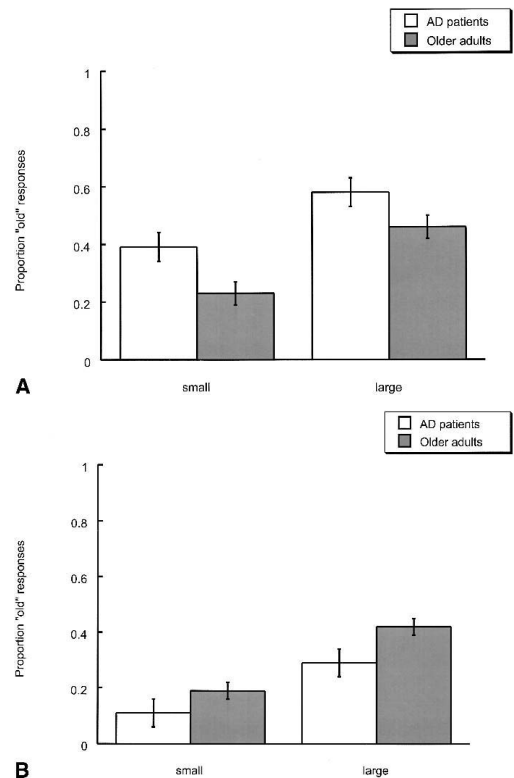| Group | True recognition | | | False recognition | | | |
|---|---|---|---|---|---|---|---|
| | Large | Small | Unrelated | Large | Small | Novel | Unrelated |
| Older adults | | | | | | | |
| M | 0.86 | 0.78 | 0.92 | 0.46 | 0.23 | 0.04 | 0.01 |
| SD | 0.16 | 0.20 | 0.11 | 0.18 | 0.18 | 0.06 | 002 |
| AD patients | | | | | | | |
| M | 0.72 | 0.63 | 0.57 | 0.58 | 0.39 | 0.28 | 0.21 |
| SD | 0.21 | 0.27 | 0.25 | 0.23 | 0.24 | 0.19 | 0.24 |

AD, Alzheimer disease.

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which no categorically related items were presented at study, thus yielding a significantly higher baseline false alarm rate for the patients with AD (Table 1; $F(1,46) = 34.34$, $p < 0.0005$).

## True Recognition

As can be seen in Table 1, patients with AD made fewer "old" responses to studied items compared with older adults, and both groups made more "old" responses to items in the large versus the small category. A 2 (Group: patients with AD versus older adults) × 2 (Category Size: small versus large) ANOVA showed effects of Group ($F(1,46) = 6.92$, $p = 0.012$) and Category Size ($F(1,46) = 10.50$, $p = 0.002$) and no Group × Category Size interaction ($F(1,46) < 0.1$). Correction for baseline false alarms by subtracting the proportion of "old" responses to the novel items from the proportion of "old" responses to the studied items showed similar results: significant effects of Group ($F(1,46) = 41.54$, $p < 0.0005$) and Category Size ($F(1,46) = 10.52$, $p = 0.002$) and no Group × Category Size interaction ($F(1,46) < 0.1$).

## False Recognition

Patients with AD made more "old" responses to nonstudied items that were in the same category as studied items for both small and large categories, compared with older adults (Table 1, Fig. 1A). Thus, our hypothesis that the trend observed in Budson et al. (20) for patients with AD to show greater false recognition than older adults for black and white line drawings simply because of the patients' perceptual impairment was disproved. Instead we found that patients with AD show greater levels of uncorrected false recognition of colored photographs compared with older adults. An ANOVA showed effects of Group ($F(1,46) = 7.87$, $p = 0.007$) and Category Size ($F(1,46) = 34.49$, $p < 0.0005$) and no Group × Category Size interaction ($F(1,46) < 1$). Because the patients showed a much higher level of baseline false alarms compared with the older adults, the analysis of the novel-corrected false recogni-



**FIG. 1.** Mean proportion of "old" responses to related lure items (**A:** uncorrected false recognition) and mean proportion of "old" responses to related lure items after false alarms to novel category items were subtracted (**B:** novel-corrected false recognition) by older adults and patients with Alzheimer disease as a function of category size. Error bars show the standard error of the mean.

tion demonstrated the opposite effect of Group: compared with the older adults, the patients with AD showed a lower level of corrected false recognition [Fig. 1B; $F(1,46) = 5.22$, $p = 0.027$]. There was also an effect of Category Size ($F(1,46) = 34.37$, $p < 0.0005$) and no Group × Category Size interaction ($F(1,46) < 1$). The effects of category size in both the corrected and uncorrected data are present because participants made more "old" responses to related lures in large versus small categories.
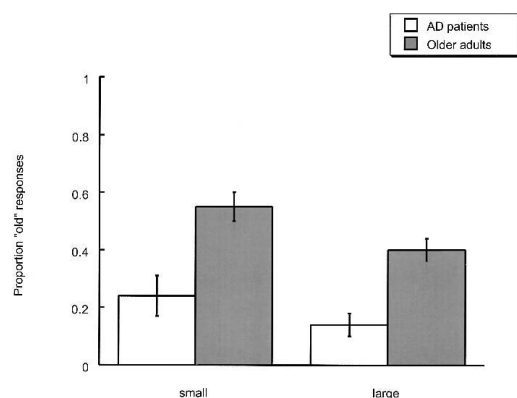
## Item-Specific Recollection: True Recognition Minus False Recognition

True recognition ("old" responses to studied items) can be thought of as a combi-

nation of gist memory plus item-specific recollection. In contrast, false recognition of related lures ("old" responses to nonstudied items from the same categories as studied items) is likely a measure of gist memory minus any item-specific recollection that is available to counteract the effect of gist. Thus, subtracting false recognition of related lures from true recognition should provide a measure of the item-specific recollection used by the groups. As can be seen in Figure 2, healthy older adults were able to develop robust item-specific recollection that, as expected, was associated with decreasing category size. In contrast to previous studies in which patients with AD were able to develop little or no item-specific recollection (12,17), in this picture paradigm patients with AD were able to generate substantial item-specific recollection, also associated with decreasing category size, although still much less than older adults. An ANOVA demonstrated significant effects of Group ($F(1,46) = 24.49$, $p < 0.0005$) and Category Size ($F(1,46) = 7.00$, $p = 0.011$) but no Group × Category Size interaction ($F(1,46) < 1$).

## DISCUSSION

Briefly reviewing our pertinent findings, patients with AD made fewer "old" responses to studied items, more "old" responses to nonstudied novel items, and consequently exhibited lower levels of corrected and uncorrected true recognition (Table 1). Thus, not surprisingly—and consistent with previous research (29)—we found that patients with AD show impairments in their memory for pictures. In contrast to the results of true recognition, patients with AD made more "old" responses to related lure items at all category sizes, compared with older adults (Table 1, Fig. 1A). Despite these uncorrected false recognition results, patients with AD showed a lower level of corrected false recognition of pictures compared with healthy older adults (Fig. 1B). This latter finding is consistent with previous studies that found that patients with AD showed lower levels of corrected false recognition of semantically related words (8,12) and perceptually related novel objects (17) compared with older adults. Both groups showed higher levels of true and false recognition with the large versus the small category size. Patients with AD showed significantly lower item-specific recollection compared with older adults, indicating that older adults were better at distinguishing between studied and related lure items than patients with AD (Fig. 2). As expected, both groups showed greater levels of item-specific recollection when fewer numbers of category exemplars were presented at study. These findings have provided us with answers to our initial questions.

First, we had discussed that previous research using a paradigm in which black and white line drawings were presented with semantically related words found a trend for patients with AD who studied and were tested with pictures to show greater uncorrected false recognition compared with older adults (20). Such a trend was not observed in paradigms with either semantically related words (12) or perceptually related novel objects (17). We suspected that this trend in Budson et al. (20) may have been due to the difficulty patients with AD experience when



**FIG. 2.** Mean proportion of "old" responses to studied items minus related lure items (item-specific recollection) by older adults and patients with Alzheimer disease as a function of category size. Error bars show the standard error of the mean.

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perceiving and identifying black and white line drawings (21,22).

However, our results did not support this suspicion. Instead, the numerical trend observed in Budson et al. (20) for patients with AD to show higher levels of uncorrected false recognition than older adults was strengthened by the significant between-group differences observed in the current study. Thus, these results suggest that the increased level of uncorrected false recognition of pictures observed in patients with AD compared with older adults is not merely due to the difficulty patients with AD may show in perceiving and identifying pictures. Such impairments are less prominent with colored photographs than with black and white line drawings (22), and yet our present study with colored photographs produced significant results.

Second, we hypothesized that whereas patients with AD show deficits in their formation and retention of gist for specific lure words (12) and category prototypes (17), they may not demonstrate such deficits in their ability to form and remember gist representations of entire categories, as in the present paradigm. Some support for this hypothesis comes from the work of Chan et al., who have shown that that not only do patients with AD exhibit impaired semantic memory, but also that their semantic networks are disordered as well (30). Thus, at least for the semantic paradigms, one reason patients with AD may exhibit degraded gist representations of the lure words is that their disordered semantic networks may not coalesce upon the specific lures as occurs in those with healthy networks. On the other hand, disorder of the semantic networks may be less important in forming gist representations of entire categories. Again, however, our hypothesis was not confirmed. Patients with AD exhibited lower levels of corrected false recognition than older adults did, suggesting that these patients are impaired in their ability to form and/or retain the gist of entire categories.

Third, we were interested in whether patients with AD—such as younger and older adults (24)—would demonstrate high levels of item-specific recollection in this paradigm using categorized color photographs, in contrast to their poor performance on this measure in previous studies using semantically related words (12) and perceptually related novel objects (17). Our present results do show, in fact, that patients with AD were able to generate reasonably high levels of item-specific recollection (Fig. 2), at least compared with their performance in the other paradigms. Presumably the rich details of the color photographs facilitate specific memories in the patients, who are then able to distinguish the previously studied photographs from those that are new but in the same category as the studied ones (at least to some extent). Older adults, however, were much better than the patients at making this distinction, and thus showed higher levels of item-specific recollection than patients with AD did. Therefore, although patients with AD show high levels of item-specific recollection of categorized color photographs relative to other paradigms, their item-specific recollection is still impaired when compared with older adults.

The current study has thus provided us with a better understanding of gist memory and item-specific recollection in AD. In addition, we have demonstrated that the elevated levels of uncorrected false recognition in patients with AD relative to older adults observed in a prior study (20) is not simply due to the patients' difficulties in perceiving and identifying the pictures. Why then is the uncorrected false recognition higher for patients with AD than for older adults in the present picture paradigm? One part of the explanation may be attributable to the ability of the healthy older adults to use the rich semantic and perceptual information in the pictures to build up high levels of item-specific recollection and reduce their false recognition. This suggestion is supported by our analysis of item-specific recollection:

older adults exhibited greater item-specific recollection than patients with AD did. The effect of category size also supports this hypothesis, because item-specific recollection was higher—and false recognition was lower—for both groups in the small versus the large category.

A second part of the explanation may be related to the patients' liberal response bias—that is, their strong, overall tendency to respond "old" ("yes, I've seen that picture") on the recognition test. The baseline false alarm rate of the patients with AD to the novel items is quite high (Table 1), suggesting that one reason for the patients' high uncorrected false recognition rate may indeed be this bias. There are multiple reasons why patients with AD may show a more liberal response bias than older adults. For example, the patients may have some sense of their memory impairment and attempt to compensate by responding "old" more frequently. Or they may more frequently respond "old" because they want to please the examiner and presume that responding "old" will do so.

Another possible explanation for this liberal response bias stems from comparisons between our results in patients with AD and previous studies of patients with amnesia. Patients with amnesia exhibit severe difficulties remembering recent experiences as a consequence of damage to the medial temporal lobes and related structures in the diencephalon, despite normal perceptual and linguistic functions and IQ scores in the normal range (31,32). In contrast to our findings in patients with AD, Koutstaal et al. (27) found that patients with amnesia showed similar or lower levels of uncorrected false recognition of categorized pictures compared with control groups. However, because their false alarms to the nonstudied novel items were higher than those of controls, patients with amnesia, like our patients with AD, exhibited lower levels of corrected false recognition of categorized pictures compared with controls.

One reason why patients with AD—but not patients with amnesia—may show a more liberal response bias and relatively higher levels of uncorrected false recognition compared with their control group is because patients with AD exhibit pathology in frontal lobes in addition to exhibiting pathology in the hippocampus and related medial temporal lobe structures. Frontal network dysfunction has been demonstrated in patients with AD by pathologic changes at autopsy (33) as well as by neuropsychologic and neuroimaging studies (34–37). Damage to the frontal lobes has been linked with high levels of false recognition (38,39). Moreover, a number of neuroimaging studies have strongly implicated various regions within the frontal lobes in episodic memory (40–43). In addition, anterior prefrontal regions may be specifically related to postretrieval monitoring and verification processes (44–47). Such processes, which may be related to the inhibitory function of the frontal lobes (48), would presumably be required to prevent unwanted responses to nonstudied items, whether related or unrelated. Patients with AD may be more impaired in these types of processes than patients with amnesia and healthy older adults, making it difficult for patients with AD to avoid responding "old" to an item that is nonstudied but similar to a studied item. [One might have expected that the subgroup of patients with amnesia reported by Koutstaal et al. (27) who are amnesic because of Korsakoff syndrome would have also shown increased levels of uncorrected false recognition compared with their control group, even if the other subgroup of patients with non-Korsakoff or "mixed" pathologic lesions (e.g., due to anoxia or encephalitis) did not. Patients with Korsakoff amnesia frequently exhibit dysfunction of frontal networks (48–51) in addition to their episodic memory dysfunction. However, both patients with Korsakoff amnesia and those with mixed amnesia showed either similar or reduced levels of uncorrected false recognition of categorized colored pictures compared with their respective control groups (27).]

In conclusion, we have shown that patients with AD exhibit lower levels of gist

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memory and item-specific recollection in a paradigm consisting of categorized color photographs. We have also shown that the elevated levels of uncorrected false recognition in patients with AD relative to older adults observed in a previous picture paradigm (20) is not simply due to the patients' difficulties in perceiving and identifying the pictures. Instead, we suspect that this pattern is attributable to the combination of the diminished ability of patients with AD to extract item-specific information from the pictures and to their inherent frontal lobe dysfunction, making them less able to inhibit responses to items that are similar but nonstudied. We can speculate that clinically relevant memory distortions may also be related to the poor ability of patients with AD to acquire item-specific information and to inhibit responses on the basis of familiarity alone. Future studies will be able to investigate whether improving item-specific recollection (by cholinesterase inhibitors, for example) and frontal lobe function (with stimulants or dopaminergic agents, for example) can reduce memory distortions in the laboratory and in daily life.

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