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Gist Memory in Alzheimer's Disease: Evidence From Categorized Pictures

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The authors investigated gist memory (the general meaning, idea, or gist conveyed by a collection of items) for categorized color photographs in patients with Alzheimer's disease (AD) using an experimental paradigm in which participants are instructed to respond "yes" when a test item fits with a previously studied category, regardless of whether the specific item was actually studied. Compared with controls, the patients endorsed fewer studied items and similar numbers of nonstudied lure items. After the authors corrected for the baseline false-alarm rate, the patients showed a lower level of endorsements for nonstudied lure items compared with that of controls, suggesting that their gist memory is impaired. Implications of these findings for understanding gist memory and response bias in patients with AD are discussed.

Keywords: Alzheimer's disease, false memory, picture memory

As the number of patients with Alzheimer's disease (AD) increases, understanding their memory impairment becomes more important (Solomon & Budson, 2003). Early diagnosis and assessment of new medications are both critically dependent on knowing exactly how memory is impaired by this disorder. We have previously explored these patients' 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 memory*; Reyna & Brainerd, 1995; Schacter, Norman, & Koutstaal, 1998). We have argued that although AD particularly damages item-specific recollection, gist memory is also impaired (Budson, Daffner, Desikan, & Schacter, 2000; Budson, Desikan, Daffner, & Schacter, 2001). The present study represents a further examination of gist memory in patients with AD.

To examine gist memory and item-specific recollection, we have used variations on a paradigm originally developed by Deese (1959) and revived and modified by Roediger and McDermott (1995). After studying lists of semantic associates (e.g., *candy*, *sour*, *sugar*, *bitter*, *good*, *taste*, etc.) that all converge on a nonpresented "theme word" or "related lure" (e.g., *sweet*), participants frequently intruded the related lure on free-recall tests (Deese, 1959) and made very high levels of false alarms to these words on recognition tests (Roediger & McDermott, 1995). As the items are presented in the Deese/Roediger–McDermott 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 this 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 (Brainerd & Reyna, 1998a; Payne, Elie, Blackwell, & Neuschatz, 1996; Schacter, Verfaellie, & Pradere, 1996). Another way of saying this is that participants may falsely recognize the lure word *sweet* when they see it at test if they remember seeing a bunch of words related to *sweet* (the gist) and they do not specifically remember that the word *sweet* was not on the study list. Therefore, the level of false recognition exhibited by participants does not necessarily indicate the amount of gist memory available to them, but rather reflects their tendency to rely on gist despite any opposing influence of item-specific recollection. By the same token, participants may correctly recognize the word *sugar* if they either specifically remember seeing the word *sugar* (item-specific recollection) or if they simply remember seeing a bunch of words related to *sweet* (the gist).

In a series of studies involving semantically related words (Budson et al., 2000), phonologically related words (Budson, Sullivan, Daffner, & Schacter, 2003), perceptually related novel objects (Budson et al., 2001), and categorized color photographs (Budson, Michalska, et al., 2003), one common finding was that patients with AD showed lower levels of false recognition after correction for the baseline false-alarm rate. (Baseline false alarms in these paradigms are nonstudied items that are unrelated to the study items.) Because the tendency to falsely recognize related lure words like *sweet* is primarily related to participants' ability to form a robust gist representation, we argued that the lower level of

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corrected false recognition observed in the patients relative to healthy older adults suggests that patients with AD show impaired gist memory.

There is, however, an alternative view espoused by Balota and others (e.g., Balota et al., 1999; Hutchison & Balota, in press; Nebes, 1989; Ober & Shenaut, 1999). When Balota et al. (1999) analyzed their results of the Deese/Roediger–McDermott paradigm for recall (rather than recognition), they found that the likelihood of false recall of lures was quite stable across healthy older adults and patients with early stage AD. If false recall is based solely on gist memory, the results of Balota et al. (1999) could indicate that gist memory is relatively intact in patients with AD.

Then again, the recall data of Balota et al. (1999) could be explained differently if older adult controls are able to use item-specific recollection to counter gist influences to a greater extent than are patients with AD. In this way, patients with AD and older adult controls might exhibit comparable levels of false recall if memory for both gist and item-specific information is impaired in the patients.

Budson et al. (2001) suggested an experiment that could help to resolve these differing interpretations. Patients with AD and older adults could be compared using an experimental paradigm in which participants are instructed to respond "yes" when a test item fits with a previously studied category, regardless of whether the specific item was actually studied (cf. Brainerd & Reyna, 1998b; Schacter, Cendan, Dodson, & Clifford, 2001; Verfaellie, Schacter, & Cook, 2002). With these modified instructions, the endorsements of related lure items would reflect the development and use of gist memory alone, rather than reflecting gist memory opposed by item-specific recollection. If the patients with AD endorsed fewer nonstudied lure items than older adults with these modified test instructions, this result would provide strong evidence for an impairment of gist-based memory. Such a result was found in a study of patients with amnesia using such instructions (Verfaellie, et al., 2002). In the present study, we used these modified test instructions in patients with AD and healthy older adults who performed a categorized pictures paradigm (used previously; Budson, Michalska, et al., 2003). We chose this paradigm in particular because it was one in which older adults and patients with AD were able to demonstrate reasonable levels of both gist memory and item-specific recollection, and also because pilot studies suggested that it would be easier to explain the modified test instructions to the patients using this paradigm than using a more typical Deese/Roediger–McDermott word-based paradigm. Lastly, to provide some assurance that the instructional manipulation was successful, another group of patients with AD and older adults controls were evaluated using standard test instructions.

A total of four groups thus participated in the experiment: (a) patients with AD in the standard instruction condition, (b) matched older adult controls in the standard instruction condition, (c) patients with AD in the modified instruction condition, and (d) matched older adult controls in the modified instruction condition. Note that great care was taken when the participants were recruited to ensure that all four groups were matched for age and education. The patients were also matched with respect to disease severity as measured by their score on the Mini-Mental State Examination (MMSE; Folstein, Folstein, & McHugh, 1975).

Finally, it is important to emphasize that, as alluded to earlier, in our studies of gist memory we have always focused on the data after they have been corrected for the level of the baseline false alarms (i.e., "old" responses to new unrelated lures). Interpreting the results of memory-impaired patient populations typically involves some type of adjustment or correction. For example, in standard recognition memory tests used in clinical practice (such as the Consortium to Establish a Registry for Alzheimer's Disease word list memory test; Morris et al., 1989), the endorsements of nonstudied items are subtracted from the endorsements of studied items to provide a "corrected" recognition performance. In this way the participant who simply endorses every item on the test whether studied or nonstudied will be scored as 0% rather than 100%. These endorsements of nonstudied items are often called baseline false alarms.

One reason why correction for baseline false alarms is important in analyzing the recognition memory performance of patients with AD is that these patients show a liberal response bias—that is, they have an overall tendency to say, "Yes, I've seen that before." Their response bias is more liberal than that of both healthy older adults and patients with amnesia. For example, Snodgrass and Corwin (1988) found that whereas patients with amnesia showed a normal response bias, patients with AD showed a liberal bias compared with their controls. This finding was despite the fact that the discrimination of the patients with AD was somewhat better than that of the patients with amnesia. Similarly, Bartok et al. (1997) found that patients with AD showed a more liberal response bias as a group compared with controls and, further, that the bias did not correlate with disease severity. Balota, Burgess, Cortese, and Adams (2002) also found that patients with mild AD showed a more liberal response bias than did older adults for high-frequency words. Therefore, in the present study we focused on data that are corrected for responses to unrelated items (i.e., new items from nonstudied categories).

Method

Participants

Twenty-seven patients with a clinical diagnosis of probable AD (National Institute of Neurological and Communications Disorders and Stroke—Alzheimer's Disease and Related Disorders Association criteria; McKhann, Drachman, Folstein, Katzman, & Price, 1984) were recruited from the Memory Disorders Unit, Brigham and Women's Hospital (BWH), Boston. These patients were each assessed by one or more of the neurologists, psychiatrists, and neuropsychologists in the clinic, all of whom are experts in the diagnosis of AD. The neuropsychological tests used for the patients' clinical diagnosis of AD varied by clinician; a sample of these tests and the clinical data may be found in Table 1. Twenty-four healthy community-dwelling older adults were recruited from participants in a longitudinal study of normal aging at BWH, from spouses and friends of the patients, and by the use of flyers and posters placed in senior centers in and around Boston. Data from 2 patients and 2 older adult controls were not used because of a problem with one counterbalancing condition. Data from 3 patients with AD were not used because of a failure to adequately understand the test instructions. Thus, the results of 11 participants in each of the four groups are presented. Written informed consent was obtained from all participants and their caregivers (where appropriate). The Human Subjects Committees of BWH and Harvard University approved the study. Participants were paid $10 per hour for their participation. Older adults were excluded if they scored below 27 on the MMSE (Folstein et al., 1975). Most patients with AD showed mild to moderate impairment on the

Table 1
Results of Standard Neuropsychological Measures in the Patients With Alzheimer's Disease

Test	Patient																					
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
Global cognition score																						
MMSE (Folstein et al., 1975)	24	29	26	18	21	25	26	25	17	21	23	27	24	23	22	16	24	24	18	25	24	23
Orientation	7	10	9	1	6	7	9	9	4	5	5	10	8	8	8	4	6	7	7	9	8	6
Registration	3	3	3	3	3	3	3	3	3	3	3	3	3	2	3	1	3	3	1	3	3	3
Attention	5	5	3	5	5	5	5	5	1	5	5	5	5	4	4	2	5	5	4	4	5	5
Recall	0	2	2	0	0	2	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0
Language	9	9	9	9	7	8	9	8	9	8	9	9	8	9	7	9	9	9	6	9	8	9
Dementia Scale (Blessed, Tomlinson, & Roth, 1968)	10	7	—	—	—	4	5	17	11	16	8	5	4	14	5	11	2	6	14	1	12	15
Dementia Rating Scale (Mattis, 1988)										122						128						
Verbal fluency (Monsch et al., 1992)																						
Letters (FAS)	33	—	—	—	67	33	—	—	43	17	8 F	16 F	27	—	39	—	68	25	14 F	—	9	16
Categories (animals, fruits, vegetables)	44	—	—	—	43	48	—	—	29	23	8 An	20 An	14	—	26	—	35	22	4 An	—	22	23
Memory (CERAD; Morris et al., 1989)																						
Word List Memory	11	16	—	—	9	17	7	—	—	5	—	15	11	—	10	—	15	13	—	11	11	—
Word List Recall	1	1	—	—	2	1	0	—	—	0	—	2	4	—	0	—	0	0	—	3	0	—
Word List Recognition	6	10	—	—	7	10	5	—	—	1	—	7	9	—	5	—	3	5	—	9	1	—
Intelligence																						
ANART (Blair & Spreen, 1989)	—	—	—	—	—	—	—	—	113	109	—	—	—	—	—	131	—	—	—	—	—	104
Naming																						
Boston Naming Test (Goodglass & Kaplan, 1983)	52 + 3	—	—	—	—	53 + 6	46	32 + 10	—	42 + 9	33 + 14	57 + 3	—	—	39 + 8	50 + 7	47	41 + 12	42 + 5	—	29 + 8	—

Note. MMSE = Mini-Mental State Examination; CERAD = Consortium to Establish a Registry for Alzheimer's Disease word list memory test; ANART = American National Adult Reading Test; F and An = word fluency for a single letter and category, respectively. The number following the plus sign for the Boston Naming Test is the number of words named following both semantic and phonemic cues.

MMSE (M = 22.6, range = 17–29). Participants were excluded if they were characterized by clinically significant depression, alcohol or drug use, cerebrovascular disease, or traumatic brain damage. All participants had normal or corrected-to-normal vision. The patients were matched to the older adults on the basis of age (patient M = 76.6 years, range = 60–86 years; older adult M = 74.3 years, range = 63–90 years), and education (patient M = 14.2 years, range = 8–20 years; older adult M = 15.9 years, range = 12–23 years). There were 12 female patients and 19 female older adult controls.

Design

The experimental design included between-subjects factors of group (patients with AD vs. older adults) and condition (standard vs. modified test instructions) and within-subjects factors of item type (studied vs. nonstudied) and category size. For studied items, category size had two 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 nonstudied items from nonstudied categories—for which no related items were present at study; these latter items provided an estimate of the baseline level 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 participants' performance on a more standard memory test.

Stimuli

The stimuli were identical to those used in Koutstaal, Verfaellie, and Schacter (2001) and consisted of colored photographs of single objects (or, in a few cases, coherent groupings of objects), without background, taken from various illustrated books for children and adults (see Figure 1). All pictures were initially mounted on white index cards and then scanned and converted to digital format using VistaScan and a UMAX Vista-S6E scanner (UMAX Technologies, Fremont, CA). 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 (Version 1.2; Cohen, MacWhinney, Flatt, & Provost, 1993).

The pictures portrayed objects from 25 different object categories, with each category consisting of a total of 21 different exemplars. The 25 categories were boats, cars, cats, whales, beds, children, drinks, shelves, butterflies, shoes, snakes, teddy bears, trees, birds, chairs, dinosaurs, motorcycles, clocks, insects, men, teapots, cacti, fish, minerals, and pens. The categories were randomly assigned to six 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 composed of 3 or 18 related items or as a nonstudied category (for the baseline false alarms). 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 (3-exemplar) category, only three items were presented at study. In these 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 (Koutstaal et al., 2001; Koutstaal & Schacter, 1997), each studied category was tested an equal number of times: three times with a studied item and three times with a lure item, in order 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 that 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 studied and nonstudied items for the studied categories, and as baseline false alarms (nonstudied items from the nonstudied categories). The nonstudied categories used as baseline false alarms were also tested three times.

For the unrelated items, 24 of a total of 30 items were chosen randomly to be used in the experiment. These were divided into two 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.

Each study list comprised a total of 102 items: items from four large categories (18 × 4), four small categories (3 × 4), 12 unrelated items, and 3 primacy and 3 recency buffers. Each test list comprised a total of 84 items: 3 studied items and 3 nonstudied items from each of the large (6 × 4) and small (6 × 4) categories, 3 nonstudied items each from four nonstudied categories (baseline false alarms; 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 BWH.

In the study phase, participants were presented with each item for 2 s and were asked to rate their liking ("like" or "dislike") for each of them. Although each picture disappeared after 2 s, the liking rating was self-paced. The pictures from different categories were randomly intermixed (not blocked as in a typical Deese/Roediger–McDermott paradigm) and the encoding task was incidental—no mention was made of a subsequent memory test. The incidental encoding task helped to ensure that all participants would use a similar encoding strategy. Participants stated their liking rating orally, and the experimenter then entered the appropriate response on the keyboard. A 5-min retention interval followed, during which participants performed simple puzzles.

Participants were then given a surprise, self-paced, recognition test with either standard or modified instructions. During this test, the item remained on the screen until the participant made a verbal "yes" or "no" response; the experimenter then pressed the appropriate key. The standard instructions were as follows:

> You will be presented with a series of pictures. Some of these pictures were presented previously. Other pictures were not presented earlier. If you recognize the picture as one that was presented earlier (before the puzzles) say, "Yes, I've seen that picture before." When you think that a picture is new (that is, it was not presented earlier), say, "No, I haven't seen that picture." For example, suppose you previously saw several different birds: a sparrow, an eagle, an owl, a hawk, a dove, and a pigeon. On the test, if you see the exact same picture of an owl you saw previously you would respond, "Yes." However, if you were presented with a different picture of an owl, a picture of a robin, a picture of another bird, or something completely different, like a table, you would respond, "No."

The modified instructions were as follows:

> You will be presented with a series of pictures. Some of these pictures were presented previously. Other pictures were not presented earlier. If you recognize the picture as one that was presented earlier (before the puzzles) or as a new item that is an example of one of the picture categories presented earlier say, "Yes, I've seen that picture before," or "Yes, that picture is in the same category as something I've seen." When you think that a picture is new (that is, it was not presented earlier) and it does not belong in one of the picture categories that you saw before, say, "No, I haven't seen that picture before and it is not from a category I saw before." For example, suppose you previously saw several different birds: a sparrow, an eagle, an owl, a hawk, a

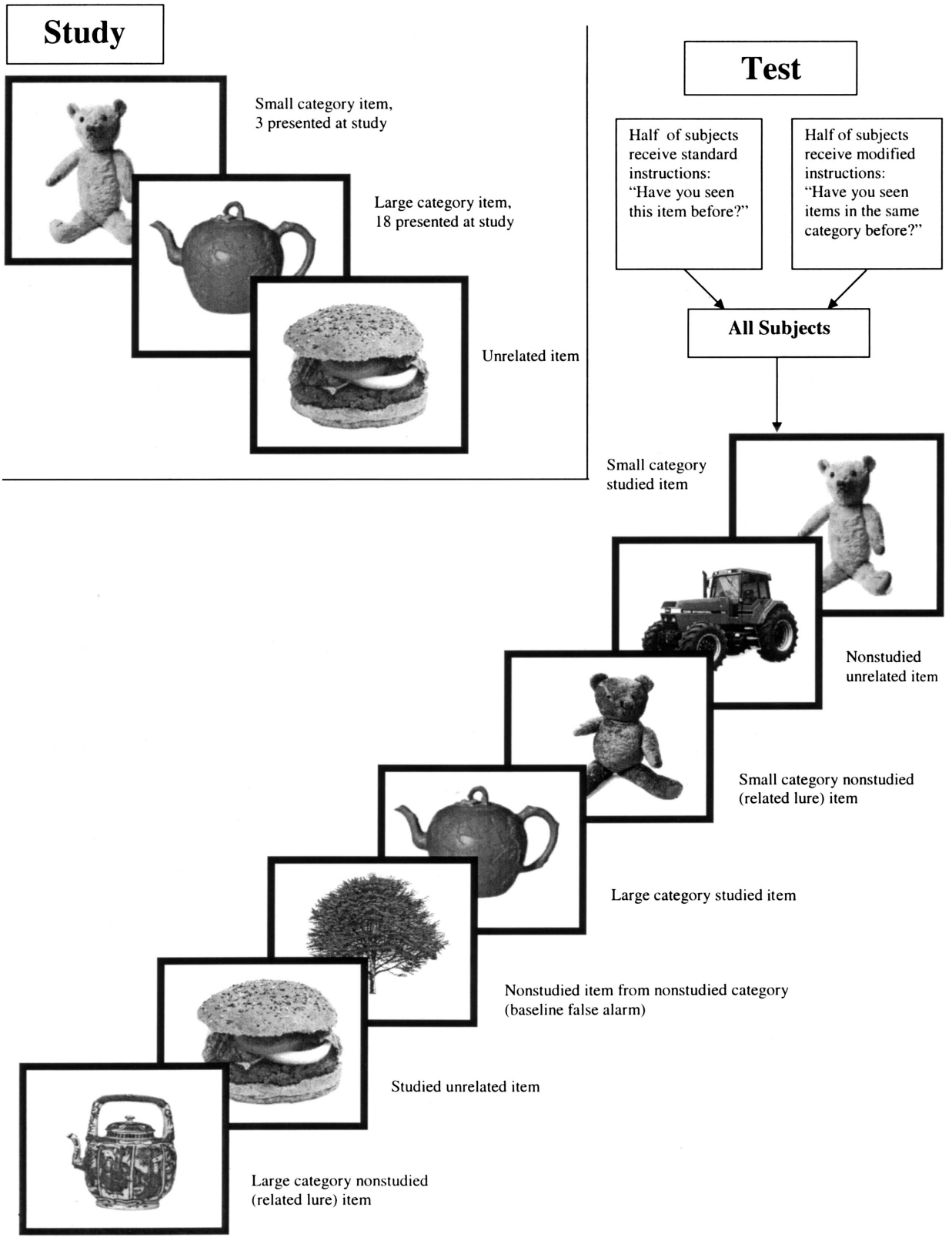

Figure 1. Schematic representation of the experimental design and the paradigm used in the present study. The test instructions in quotations paraphrase the full instructions given to participants, which may be found in the Method section. Note that although the stimuli are shown here in grayscale for illustrative purposes, the stimuli were presented to participants in color.

dove, and a pigeon. On the test, if you see the exact same picture of an owl you saw previously, a different picture of an owl, a picture of a robin, or a picture of another bird, you would respond, "Yes." However, if you were presented with something completely different, like a table, you would respond, "No."

Participants were required to paraphrase the instructions back to the experimenter, and additional explanations were given to the participants if necessary.

Results

Table 2 presents the proportion of endorsement of studied and nonstudied items from large and small studied categories; nonstudied items studied from new, nonstudied categories that serve as baseline false alarms; and studied and nonstudied unrelated items that are not related to any categories. The nonstudied items from nonstudied categories (baseline false alarms) consisted of 12 items, 3 each from 4 of the 25 different object categories that were not presented during the study session. For example, if trees, insects, cacti, and fish were categories that were not presented during the study session for a particular participant, the nonstudied items from nonstudied categories for that participant could consist of 3 trees, 3 insects, 3 cacti, and 3 fish. (The counterbalancing of stimuli ensured that these same items from these categories would be studied items for other participants.) The nonstudied unrelated items consisted of 12 individual items that were not related to each other, were not part of any category, and were not presented during the study session. For example, nonstudied unrelated items could include a hotdog, a skateboard, a girl, a basketball, a sock, an orangutan, a piece of cheese, a briefcase, a hat, a building, a cloud, and a pretzel. (Again, the counterbalancing of stimuli ensured that these same 12 unrelated items would be studied items for other participants.) These unrelated items provide performance on a typical memory test. Studied and nonstudied items from large and small categories after correction for baseline false alarms are presented in Table 3, as are the studied unrelated items after correction for the nonstudied unrelated items. Participants in the standard condition are provided mainly for comparison with those in the modified condition, to provide some assurance that the instructional manipulation was effective. Comparisons are therefore presented first between those in the standard and modified conditions, and then between the patients with AD and older adults in the modified condition. Because (being unstudied) there is no manipulation of category size for the baseline false alarms (nonstudied items from nonstudied categories), interactions with category size for the corrected items will necessarily be the same as for the uncorrected data, and are therefore not presented. Because of the small numbers of participants, effect sizes are presented for all significant and also important nonsignificant effects and interactions.

All Participants: Standard Versus Modified Test Instructions Conditions

For these analyses, only the effect of condition and interactions with condition were of interest, as the results of a similar study under standard conditions have been published (Budson, Michalska, et al., 2003) and the full analysis of those in the modified condition is presented later in this article.

An analysis of variance (ANOVA) for the main item types with group (patients with AD vs. older adults) and condition (standard vs. modified test instructions) as between-subjects variables and studied status (studied vs. nonstudied) and category size (small vs. large) as within-subject variables yielded a main effect of condition, $F(1, 40) = 28.62$, $MSE = 0.099$, $p < .0005$, $\eta^2 = .42$, indicating that participants endorsed more items when given the modified instructions than when given the standard instructions (see Table 2). There was a Studied Status × Condition interaction, $F(1, 40) = 17.46$, $MSE = 0.025$, $p < .0005$, $\eta^2 = .30$, because the effect of studied status was less for those in the modified condition, $F(1, 20) = 24.17$, $MSE = 0.035$, $p < .0005$, $\eta^2 = .55$, than for those in the standard condition, $F(1, 20) = 213.70$, $MSE = 0.016$, $p < .0005$, $\eta^2 = .91$. There was also a near significant Studied Status × Group × Condition interaction, $F(1, 40) = 3.58$, $MSE = 0.025$, $p = .066$, $\eta^2 = .08$, which was present because the effect of studied status was less for the patients with AD than the older adults in the standard condition—Studied Status × Group interaction: $F(1, 20) = 15.90$, $MSE = 0.016$, $p = .001$, $\eta^2 = .44$—but similar between these groups in the modified condition—Studied Status × Group interaction: $F(1, 20) < 1$. Lastly, there was a trend toward a Category Size × Condition interaction,

Table 2
Endorsement of Studied and Nonstudied Items

	Standard instructions				Modified instructions			
	Older adults		Patients with AD		Older adults		Patients with AD	
Variable	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
Studied items								
Items from large studied categories	.83	.18	.70	.19	.98	.03	.92	.15
Items from small studied categories	.83	.15	.65	.22	.95	.09	.77	.22
Unrelated items	.93	.12	.60	.23	.96	.08	.58	.29
Nonstudied items								
Items from large studied categories (related lures)	.46	.20	.52	.18	.98	.05	.89	.19
Items from small studied categories (related lures)	.19	.17	.27	.28	.54	.44	.45	.39
Items from nonstudied categories (baseline false alarms)	.09	.17	.20	.18	.06	.08	.33	.30
Unrelated items	.02	.08	.17	.26	.08	.10	.30	.22

Note. AD = Alzheimer's disease.

Table 3
Corrected Endorsement of Studied and Nonstudied Items

Variable	Standard instructions				Modified instructions			
	Older adults		Patients with AD		Older adults		Patients with AD	
	M	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
Corrected studied items								
Items from large studied categories minus baseline false alarms	.74	.23	.50	.24	.92	.10	.59	.36
Items from small studied categories minus baseline false alarms	.73	.16	.45	.29	.89	.14	.45	.37
Unrelated items minus nonstudied unrelated items	.84	.21	.39	.32	.88	.11	.27	.29
Corrected nonstudied items								
Items from large studied categories minus baseline false alarms	.37	.24	.31	.23	.92	.10	.56	.38
Items from small studied categories minus baseline false alarms	.10	.20	.06	.31	.48	.44	.12	.44

Note. AD = Alzheimer's disease.

$F(1, 40) = 3.43$, $MSE = 0.044$, $p = .071$, $\eta^2 = .08$, because the effect of condition was greater for large categories, $F(1, 40) = 47.36$, $MSE = 0.045$, $p < .0005$, $\eta^2 = .54$, than for small categories, $F(1, 40) = 8.56$, $MSE = 0.098$, $p = .006$, $\eta^2 = .18$. There were no Group × Condition, Category Size × Group × Condition, Studied Status × Category Size × Group × Condition, or Studied Status × Category Size × Condition interactions, Fs(1, 40) < 1 except the last interaction, $F(1, 40) = 1.42$, $MSE = 0.029$, $p = .242$, $\eta^2 = .03$.

Participants in the Modified Test Instructions Condition

Unrelated items. A series of one-way ANOVAs for the items unrelated to any of the categories demonstrated that compared with older adults, patients with AD endorsed fewer studied unrelated items, $F(1, 20) = 18.24$, $MSE = 0.045$, $p < .0005$, $r^2 = .48$, and greater nonstudied unrelated items, $F(1, 20) = 8.83$, $MSE = 0.030$, $p = .008$, $r^2 = .31$, and thus showed a much lower level of corrected studied unrelated items (studied unrelated items minus nonstudied unrelated items), $F(1, 20) = 41.29$, $MSE = 0.049$, $p < .0005$, $r^2 = .67$ (see Tables 2 and 3).

Nonstudied items from nonstudied categories (baseline false alarms). A one-way ANOVA showed that patients with AD endorsed greater nonstudied items from new, nonstudied categories compared with older adults, $F(1, 20) = 8.00$, $MSE = 0.048$, $p = .010$, $r^2 = .29$ (see Table 2).

Studied items from studied categories. An ANOVA for the studied items with group (patients with AD vs. older adults) as a between-subjects variable and category size (small vs. large) as a within-subject variable demonstrated an effect of group, $F(1, 20) = 5.81$, $MSE = 0.030$, $p = .026$, $\eta^2 = .23$; an effect of category size, $F(1, 20) = 7.21$, $MSE = 0.012$, $p = .014$, $\eta^2 = .27$; and weak trend toward an interaction, $F(1, 20) = 3.07$, $MSE = 0.012$, $p = .095$, $\eta^2 = .13$ (see Table 2). The effect of group is present because patients with AD endorsed fewer studied items than older adults. The effect of category size demonstrates that participants overall endorsed greater numbers of studied items at test from large categories compared with small categories, and the weak trend toward an interaction is present because this effect of category size was significant in the patients with AD, $t(10) = 2.38$, $SEM = 0.061$, $p = .039$, but not in the older adults, $t(10) = 1.31$, $SEM = 0.032$, $p = .221$. Not surprisingly, the corrected data (studied items from studied categories minus baseline false alarms) also showed an effect of group, $F(1, 20) = 12.33$, $MSE = 0.136$, $p = .002$, $\eta^2 = .38$, indicating that the patients with AD showed a lower level of corrected studied items compared with the older adults (see Table 3).

Nonstudied items from studied categories (related lures). An analogous ANOVA for the nonstudied items from studied categories showed an effect of category size, $F(1, 20) = 24.45$, $MSE = 0.087$, $p < .0005$, $\eta^2 = .55$; no effect of group, $F(1, 20) < 1$, $\eta^2 = .04$; and no interaction, $F(1, 20) < 1$ (see Table 2). The effect of category size demonstrates that participants overall endorsed greater nonstudied items at test from large categories compared with small categories. The lack of an effect of group indicates that the patients with AD did not endorse fewer nonstudied items from studied categories than older adults. Analysis of the corrected data (nonstudied items from studied categories minus baseline false alarms), however, revealed that patients with AD did show a lower level of corrected nonstudied items from studied categories compared with the older adults, $F(1, 20) = 7.74$, $MSE = 0.180$, $p = .012$, $\eta^2 = .28$ (see Table 3).

Discussion

In this study, we sought to determine, using a false memory paradigm, whether gist memory is impaired in patients with AD. Pictures from several different categories were presented at study along with a number of unrelated items. At test, participants were shown studied items from these categories, nonstudied items from these categories (related lures), nonstudied items from nonstudied categories (baseline false alarms), and studied and nonstudied unrelated items. In standard false memory paradigms, the test instructions are to only endorse studied items. In these standard paradigms, the related lure false-alarm rate is a function of two things: how much gist the participants developed for the studied categories (which would tend to increase their false recognition) and the amount of item-specific recollection they were able to use (which would tend to decrease their false recognition). In the present study, we used four groups of participants. Two of these groups (patients with AD and healthy older adult controls) performed the experiment with the standard test instructions. Another

two groups (other patients with AD and healthy older adult controls) performed a modified experiment in which participants were instructed to endorse both studied items and related lures (nonstudied items from studied categories). In this modified false memory paradigm, the related lure false-alarm rate would be a function only of how much gist participants developed for the studied categories.

Our analyses of the standard versus modified test instructions conditions suggest that our instructional manipulation was successful. The modified instructions eliminated the need for gist memory to be opposed by item-specific recollection. As expected, both older adults and patients with AD endorsed greater numbers of items in the modified versus the standard condition (see Table 2).

Our primary comparison of interest, however, was whether with the modified test instructions the patients with AD would endorse fewer related lures than did healthy older adults. In the analysis of the uncorrected data, we found that patients and older adults made very similar numbers of endorsements of related lures. Although the number of participants in our study was not large, and there were numerical differences between the groups, the fact that $\eta^2 = .04$ indicates that the effect of group only explains 4% of the variance of the data. However, patients with AD made fewer endorsements of related lures after correction for baseline false alarms ($\eta^2 = .28$).

Thus, the results of the present study provide the compelling evidence we expected—suggesting that gist memory is impaired in patients with AD—for the analysis of these corrected data, but not for the analysis of these uncorrected data. If corrected data provide the most accurate measurement of gist memory, then our present results would provide support for the notion that gist memory is impaired in AD. However, if uncorrected data provide the most accurate measurement of gist memory, then our results would suggest that gist memory is intact in AD. As we argued in the introduction, we believe that correcting for the liberal response bias of the patients is necessary to compare their results with those of the older adult controls, and therefore we believe that the present study does provide strong evidence that gist memory is impaired in AD. This finding is consistent with the study of Chapman and colleagues, who found that patients with AD and mild cognitive impairment are also impaired in both gist and detail levels of discourse processing (Chapman et al., 2002), suggesting that patients with AD may be impaired in multiple kinds of gist.

Before we discuss the implications of this study for gist memory in AD, we first turn to an examination of the liberal response bias (the elevated baseline false-alarm rate) observed in these patients, given its importance in interpreting our results. We think it likely that one of two factors may be responsible for this bias.

First, Snodgrass and Corwin (1988) suggested that if the stimuli are not encoded distinctively during the study session, semantic memory representations might become inappropriately activated. Nonstudied items presented during the test session may match these inappropriately activated representations, producing a false sense of familiarity, which in turn would produce an endorsement of those nonstudied items, raising the baseline false-alarm rate. Applying this theory to the present article, the notion is that the gist representation formed by patients with AD may be more broad and/or diffuse than that formed by healthy older adults. Supporting this notion, work by Chan and colleagues (Chan et al., 1993; Chan, Butters, & Salmon, 1997) has provided evidence that the semantic networks of patients with AD are disorganized. In addition, Alathari, Trinh, and Dopkins (2004) found that patients with AD show a broader pattern of semantic priming than that of healthy older adults. Thus, the same items at encoding that produce a focused gist representation of "cats" in older adults may produce a broader gist representation in patients with AD that includes not only "cats" but also "household animals" (such as "dogs" and "birds") and "great cats" (such as "leopards," "tigers," and "lions"). The older adult will therefore not endorse the novel, unrelated picture of a "tiger" presented on the test, but the patient with AD very well may.

A second possibility is that the liberal response bias in patients with AD may be primarily attributable to the patients' difficulty in inhibiting a "yes" response. Inhibitory controls are thought to be a primary function of the frontal lobes (Shimamura, 1995). Patients with AD show pathological changes in the frontal lobes at autopsy (Lidstrom et al., 1998), and neuropsychological and neuroimaging studies of patients with AD have demonstrated frontal lobe dysfunction (Baddeley, Baddeley, Bucks, & Wilcock, 2001; Baddeley, Bressi, Della Sala, Logie, & Spinnler, 1991; Dalla Barba, Nedjam, & Dubois, 1999; Haxby et al., 1988; Mountjoy, Roth, Evans, & Evans, 1983). One reason why a "yes" response may be attractive is that participants often want to please the experimenter, and they may think that if they respond "no" too much, they are not being "a good subject." Another reason why participants may show a tendency to endorse nonstudied items is that the pictures remain on the screen until the participant responds. Although we did not record reaction time data, it was clear that the patients took longer to respond than the older adults. An interesting possibility is that as the item is observed on the screen over time, it becomes more familiar and is thus more likely to be endorsed.[1] Whereas healthy older adults are able to inhibit responding solely on the basis of such weak familiarity or tendencies to please the experimenter, patients with AD may be less able to inhibit such responses because of their frontal lobe dysfunction.

To distinguish between these two possibilities, we conducted the following post hoc examination of the unrelated false alarms made by the patients with AD in the modified condition. Each nonstudied unrelated item that was falsely endorsed by a particular patient with AD was compared with the studied items seen by that patient by two raters, who rated the item as "very related," "somewhat related," or "truly unrelated" to the studied items. In the case of a difference of opinion between the raters, a third rater served as a tiebreaker. If the majority of the items that were falsely endorsed by the patients were either very or somewhat related, this finding would suggest that the patients' diffuse gist representation was responsible for their liberal response bias. If, however, the items that were falsely endorsed were evenly distributed between those that were either very or somewhat related and those that were truly unrelated, this finding would suggest that the patients' liberal response bias was attributable to other factors, such as poor response inhibition.

The patients with AD in the modified condition falsely endorsed an average of 3.64 items or 30% of the 12 nonstudied unrelated

[1] We speculate that this phenomenon may be a weak form of the *revelation effect*, which typically involves solving some type of problem with the test item (Peynircioglu & Tekcan, 1993).

items presented at test (see Table 2). Of these falsely endorsed items, none were rated as very related, an average of 1.45 items or 40% were rated as somewhat related, and an average of 2.18 or 60% were rated as truly unrelated. Thus, we found that the pattern of falsely endorsed items was roughly evenly split between those items that were somewhat related and those that were truly unrelated—there was not even a trend toward greater endorsement of related items (if anything, there were more false alarms to the truly unrelated items). This finding is consistent with the idea that factors such as impaired response inhibition—and not diffuse gist memory—may be responsible for the liberal response bias in the patients with AD in the present research.

Understanding the etiology of the liberal response bias in the patients with AD in the present study explains why correcting our data for the baseline false-alarm rate is both necessary and appropriate. We turn now to a discussion of our primary finding, that gist memory is impaired in patients with AD.

Exactly why the patients' gist memory is impaired is unknown. Some data suggest that the infero-lateral temporal lobes, known to be involved in AD (Price & Morris, 1999), are critically important in semantic memory (Damasio, Grabowski, Tranel, Hichwa, & Damasio, 1996; Perry & Hodges, 1996). The strength and/or coherence of the semantic gist representation may thus be impaired because of the degradation of the infero-lateral temporal lobes in AD.

Another possible explanation is that poor attention during encoding may make it difficult for patients to form or encode a gist representation in the first place. Formation and encoding of gist information may partly depend on automatic activation processes (Brainerd & Reyna, 2001; McDermott & Watson, 2001; Roediger & McDermott, 2004), in which activation of the semantic representation of one item spreads to related concepts. Although the automatic activation processes may be intact in AD, as supported by studies of semantic priming (e.g., Balota & Duchek, 1991), the attentional control system that focuses attention itself is likely dependent on the frontal lobes (Balota et al., 1999), which, as mentioned earlier, are known to be involved in AD (Baddeley et al., 1991, 2001; Dalla Barba et al., 1999; Haxby et al., 1988; Lidstrom et al., 1998; Mountjoy et al., 1983). If there is impairment of such a control system, the patients may either fail to adequately direct their attention to the study items or fail to provide adequate effort to encode them.

Finally, there is evidence that gist memory and the gist representations themselves are critically dependent on the medial temporal lobes (Cabeza, Rao, Wagner, Mayer, & Schacter, 2001; Goldmann et al., 2003; Schacter & Slotnick, 2004; Verfaellie et al., 2002), which are most involved in AD (Price & Morris, 1999). Dysfunction of the medial temporal lobes may impair gist memory at several stages. If the patients have trouble remembering the studied items, it will be difficult for a gist representation to form. If a gist representation is formed, its encoding or retention in memory may be impaired. The formation of a gist representation may thus be relatively spared in AD when demands on episodic memory are low, such as when participants are tested immediately after the presentation of a single list of semantic associates (as in the recall data of Balota et al., 1999), but memory for those gist representations may be impaired when demands on episodic memory are high, such as following a delay or following administration of multiple lists of associates (as in the present experiment and those by Budson et al., 2000, 2001; Budson, Michalska, et al., 2003; and Budson, Sullivan, et al., 2003). Future studies of patients with AD that compare memory for gist information after single and multiple list presentations, with and without delays, will be helpful in better understanding the gist memory in AD.

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