Category Knowledge in Alzheimer's Disease: Normal Organization and a General Retrieval Deficit

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Three hypotheses that could account for deficits in the retrieval of category information in Alzheimer's disease (AD) were evaluated: abnormal organization, class- or category-specific vulnerability, and limitation by general factors, such as decreased processing speed. Relative to 18 elderly control subjects, 18 patients with AD produced fewer items in a category fluency task and had longer reaction times in a category decision task. The pattern of performance across categories on both tasks was normal in the AD group: The same categories elicited the most (or fastest) responses in both the control group and the AD group. AD patients showed normal performance in ranking of category exemplars by typicality. There was no evidence for differential accessibility by category or by class of information (animate vs. inanimate). The authors conclude that a general factor or factors limit(s) retrievability equally across all categories.

Alzheimer's disease (AD) is characterized by deficits in the retrieval of semantic knowledge (see Nebes, 1989, for a review). Retrieval problems are manifested in AD by several types of aberrant responses, including a reduced ability to exhibit information, as seen on fluency tasks, when patients produce few members of a target category; a tendency to produce responses to a target that are incorrect, but semantically related to the target (e.g., calling a comb a brush); and a reduction in speed of responding to requests for semantic information, as seen on reaction time tasks. Possible explanations for impaired retrieval in AD are (a) that the underlying organization of semantic knowledge is abnormal; (b) that specific types of semantic information are differentially difficult to retrieve; and (c) that a general factor, such as decreased processing speed, places limits on how much or how quickly semantic information can be retrieved.

In support of the first hypothesis of abnormal organization of semantic information, Grober, Buschke, Kawas, and Fuld (1985) reported that patients with dementia of various etiologies, including AD, performed normally when deciding whether a word was a semantic associate of a target concept word, but performed abnormally when ranking three such associates in order of importance to understanding the concept. In other words, the underlying organization of the semantic information was available to demented subjects under certain task conditions, but that there was a disruption of the relative weights that determine salience of an associate to a semantic concept. In other words, the underlying organization of the semantic information was abnormal in dementia. Nebes and Brady (1990) discounted this hypothesis with their finding that the time needed by AD patients to judge whether a word was an associate of a target varied with the saliency of the associate, just as it did in normal subjects. In regard to category information, the results of two studies suggested normal organization. On an object-sorting task, AD patients were like normal elderly subjects in showing impaired performance mainly when the target category was implicit rather than explicit (Flicker, Ferris, Crook, & Bartus, 1986); and on a task of verbal fluency, AD patients had a normal distribution of high-dominant and low-dominant category items (Ober, Dronkers, Koss, Delis, & Friedland, 1986).

The second hypothesis, that there is a selective vulnerability of certain words or classes of words to loss or reduced accessibil-
ity, gained support from the findings of Huff and colleagues (Huff, Corkin, & Growdon, 1986; Huff, Mack, Mahlmann, & Greenberg, 1988). In these studies, patients with AD made errors on the same items in picture naming and in name recognition or definition, suggesting that semantic deficits involve a loss of information about specific objects and their names, rather than a general disruption in the organization of semantic information. Supporting the idea of selective vulnerability is the finding by Ober and Shenhaut (1988) that the normal slowing on lexical decision to low-frequency words relative to high-frequency words was exacerbated in AD. By contrast, Ober et al. (1986) found that AD patients did not selectively lose low-dominant exemplars of categories, and Nebes, Bolner, and Holland (1986) reported a normal dominance effect in AD on category decision, leaving open the question of whether loss or deficient retrieval occur differentially for various classes of information.

The third possible explanation for retrieval deficits, that there is a general factor that limits retrieval, derived from work with healthy elderly subjects (Salthouse, 1985a, 1985b) and patients with AD (Nebes & Brady, 1990; Nebes & Madden, 1988). According to these workers, aging and dementia are associated with general decreases in the speed of information processing. Another possible general factor that would limit retrieval is task difficulty. In a recent study, Bayles, Tomoeda, Kaszniaik, and Troset (1991) determined that "item-specific loss" by AD patients tended to occur mainly on the most difficult tasks and increased in frequency with increasing dementia severity. They concluded that it may be impossible to answer the question of whether AD results in item-specific loss when tasks are used that make significant demands on conscious processing. Presumably, retrieval deficits that are related to general factors such as processing speed or task difficulty would not be limited to the domain of semantic memory.

A major difficulty in assessing the relative merits of these competing hypotheses is that the type of semantic information under evaluation has been different in each study. It is possible that different domains of semantic information are affected to different extents in AD (e.g., Nebes, 1989). In the present study, we focused on one kind of semantic knowledge (category knowledge) and tested the hypotheses of impaired overall organization, selective disruption of particular classes of information, and general limiting factors in AD. Our results indicated that the organization of category knowledge is preserved in AD. Furthermore, we found no evidence for class-specific or category-specific retrieval deficits. Certain categories permitted faster or easier retrieval of their members than others, but this finding applied to healthy elderly subjects as well as to patients with AD. In addition, there appeared to be a constant factor that separated the performance of AD patients and control subjects across all categories, regardless of the absolute level of performance in any one category. The factor influenced speed of response, as reflected in reaction time performance on a category decision test, and also the ability to retrieve any information, as reflected in performance on a test of verbal fluency.

Method

Subjects

The performance of 18 patients with AD (9 women, 9 men) was compared with that of 18 elderly control (EC) subjects (12 women, 6 men) who were matched to the AD group for age and education level. Mean age was 68.2 years (SD = 7.3) for the AD patients and 67.8 years (SD = 5.5) for the EC subjects. Mean education was 15.2 years (SD = 3.3) for the AD patients and 14.1 years (SD = 2.1) for the EC subjects. All subjects had completed at least 12 years of education, spoke English as their native language, and were living at home in good health. The EC subjects were spouses or siblings of the patients with AD, or healthy volunteers from the community.

The diagnosis of probable AD was established in accordance with published guidelines (McKhann et al., 1984). Dementia severity for the AD patients ranged from mild (6.0) to severe (32.5; M = 16.4, SD = 7.9) as measured with the full-scale Blessed Dementia Scale (BDS; Blessed, Tomlinson, & Roth, 1968). All 13 EC subjects who received the full-scale BDS scored 2 or less, indicating normal performance (M = 0.7, SD = 0.6). The other 5 EC subjects received the BDS subscale assessing information, memory, and concentration, and all scored in the normal range of 3 or less (M = 0.6, SD = 1.3). All AD patients (or their caregivers) and EC subjects completed a health history questionnaire, and all received a full neurological examination to rule out past or present neurological conditions. Exclusion criteria for both groups included cancer or serious chronic medical illness; serious cardiac disease; Hachinski ischemic score of greater than 6 (Hachinski et al., 1975); Diagnostic and Statistical Manual of Mental Disorders (3rd ed., rev.; DSM-III-R; American Psychiatric Association, 1987) diagnosis or neurological diagnosis other than AD; use of psychoactive drugs; and mental retardation.

Procedure

The category fluency test was always given first, at least 2 hours and usually 24 hours before the other tests. The order of administration of the other two tests, category exemplar ranking and category decision, was determined only by equipment availability. Tests were separated by administration of unrelated tasks or by rest breaks, to avoid repetition priming between tasks. Within the category decision test, the dominance subtest was followed (usually within 4 hours) by the word reading subtest.

Category fluency. Subjects heard a target category name and then named as many unique members of that category as possible in 1 min per category. The 10 categories tested were four-legged animals, birds, clothing, fruit, furniture, parts of the human body, insects, musical instruments, vegetables, and vehicles.

Category exemplar ranking. Subjects were shown the name of a superordinate category on a card, and three cards, each with a different word representing exemplars of the superordinate category, were placed beneath the category name. The examiner asked the subject to point to the card with "the most typical member" of the target category. If necessary, the most typical member was further described as the "most representative member," or "the one that comes to mind first when you think of this category." For example, for the category vegetables, the subject viewed the words onion, turnip, and carrot, and was asked which was the most typical vegetable. The correct first choice was carrot, a highly typical exemplar of the category. The card with the chosen word was subsequently removed by the examiner. Subjects then pointed to the word of the remaining two that was the more typical exemplar of the category. In the example, onion was a more typical vegetable than turnip. Subjects thus provided a 1-2-3 ranking of the three exemplars of the category on the basis of typicality (the 3 rank being by default). In the example, the correct ranking was carrot, onion, and turnip.

There were two trials for each of the 10 categories tested, with no repetition of items from trial to trial. The categories were the same as those used in the fluency test. Exemplar words were drawn from norms (Battig & Montague, 1969) that gave the dominance rating for category exemplars, which is a measure of the strength of association.
between the category name and individual exemplars. Each trial included one high-dominant exemplar (HDE), one medium-dominant exemplar (MDE), and one low-dominant exemplar (LDE). Mean dominance ratings reflect the percentage of Battig and Montague’s normative sample of 442 subjects who produced that exemplar when asked to list members of a target category. Across all trials, mean dominance ratings were as follows: HDE, \( M = 61.9, SD = 21.2 \); MDE, \( M = 19.0, SD = 10.5 \); LDE, \( M = 1.5, SD = 0.5 \). HDE, MDE, and LDE were matched for mean word length over the 20 trials: HDE, \( M = 6.2, SD = 1.9 \); MDE, \( M = 6.0, SD = 2.0 \); LDE, \( M = 6.7, SD = 2.4 \), letters per word.

**Category decision: dominance.** A question incorporating the name of a superordinate category appeared at the top of a monitor screen and was read aloud by the examiner (e.g., Is the next word a kind of category name?). Five sec after the question appeared, a word representing a possible exemplar of the given category was presented beneath the question, in the center of the screen. The task was to read the word silently and judge whether it was an exemplar of the given category, and to answer “yes” or “no” aloud as quickly as possible. The measure was voice-activated reaction time (RT), which was recorded by microcomputer.

Category members were either high-dominant exemplars or low-dominant exemplars of the same 10 categories used in the fluency and exemplar ranking tests. For example: (question) Is the next word a kind of vegetable? (word) carrot; (correct response) “yes.” Carrot is an HDE of the category vegetables, as per Battig and Montague (1969) norms; turnip is an example of an LDE. Across categories, dominance ratings, as defined for the ranking test, were \( M = 65.0, SD = 19.8 \) for HDE, and \( M = 5.8, SD = 4.0 \) for LDE. HDE and LDE were matched for mean word length across all trials: HDE, \( M = 5.6, SD = 1.8 \); LDE, \( M = 5.6, SD = 2.2 \), letters per word. The difference in RT to HDE and LDE was the measure of the dominance effect.

There were 120 trials. The first 40 trials were novel. In the following 80 trials, the original 40 trials were repeated, randomly mixed with 40 novel trials. The test thus consisted of 80 novel and 40 repeated trials. The 80 novel trials comprised 8 trials (4 with HDE, 4 with LDE) of each of the 10 categories. Each exemplar appeared in only 1 trial. For the novel (and repeated) trials, the correct answer was “yes” to one half of the trials. For the rest of the trials, the exemplar was not a member of the question category, but instead was a member of one of the other 9 categories. One half of the trials used the same 20 HDE and 20 LDE as were used in the ranking test, supplemented by and randomly mixed with 20 more each of HDE and LDE.

The 40 repeated trials comprised 8 trials (4 with HDE, 4 with LDE) of each of 5 of the 10 categories, with exposure to the first or second group of 5 categories being balanced across subjects. The repeated trials were used to address a separate issue from that of the present article, and will not be discussed further here. All references in the Results section will be to the 80 novel trials only.

**Category decision: word reading.** After the category decision and recognition tests were completed, subjects again saw on the monitor screen all of the words from the category decision test, but without the questions, and read each word aloud as quickly as possible. The measure was voice-activated RT. This task served as a control for the category decision test, in that it permitted comparison of RTs for reading HDE words with RTs for reading LDE words.

**Results**

**Category Fluency**

The AD patients produced significantly fewer items per category than the EC subjects (\( t = 7.6, p < .01 \); all \( t \) tests reported here are two-tailed. See Table 1). The AD patients produced a mean of 50.6% of the number of items produced by the EC subjects, with a range of 41% to 61% for individual categories. From each of the two sets of data, a Pearson product-moment correlation coefficient was calculated that related the category-by-category performance of the AD patients to the EC subjects. In contrast to the large difference in absolute levels of performance for the two groups, their pattern of performance was strikingly similar: Those categories that elicited relatively few (or many) items from EC subjects were the same categories that elicited relatively few (or many) items from the AD patients, \( r (8) = .97, p < .01 \) (Figure 1). Performance of the AD patients was correlated with dementia severity, \( r (16) = -.77, p < .01 \).

Because of recent interest in the possibility that AD is associated with specific deficits in knowledge of animate objects (Silveri, Daniele, Giustolisi, & Gainotti, 1991), we performed post hoc analyses comparing performance on three animate categories (animals, birds, and insects) with performance on three inanimate categories (furniture, musical instruments, and vehicles). AD patients produced fewer items than EC subjects, and for both groups animate categories elicited fewer responses than inanimate categories, but there was no interaction between subject group and category group (Table 1).

**Category Exemplar Ranking**

The mean number correct (of 20 trials), collapsing data across the 10 categories, was calculated for each group in two ways, comparable to the method used by Grober et al. (1985). One score described the number of trials in which the subject ranked the HDEs as correct, regardless of whether the MDEs and LDEs were also ranked correctly. A second score described the number of trials in which the subject correctly ranked the entire three-item sequence (HDE, MDE, and LDE).

The EC subjects and AD patients performed equivalently for ranking words in order of dominance across categories. Mean number correct of 20 trials were as follows, with correct defined as correct ranking of the HDE: AD patients, \( M = 14.6, SD = 2.1 \); EC subjects, \( M = 15.8, SD = 2.2 (t = 1.6, p = .11, ns) \). With correct defined as correct ranking of all three items, the results were as follows: AD patients, \( M = 7.5, SD = 2.9 \); EC subjects, \( M = 7.9, SD = 2.8 (t = 0.5, p = .64, ns) \). Within the AD patient group, there was no significant correlation between performance on the ranking test and dementia severity as measured with the BDS, either for the condition in which HDE was correct, \( r (16) = -.24 \), or for the condition in which all three items were correct, \( r (16) = -.10 \).

Mean number correct was also determined for each of the 10 individual categories, in the same way described above; once to measure the ability to correctly rank the HDE, and once to measure the ability to correctly rank the entire three-item sequence. A Pearson product-moment correlation coefficient was calculated that related the category-by-category performance of the AD patients to the EC subjects. For the HDE accuracy measure, the correlation between AD patients' and EC subjects' performance was significant, \( r (8) = .80, p < .01 \). The correlation was positive, but not significant, for the measure of entire-sequence accuracy, \( r (8) = .39 \). The results suggest that, at least for the ranking of the most typical category exemplar, AD patients and EC subjects performed very similarly, regardless of the specific category being assessed.

Besides measuring performance on each category alone and across all categories, we also assessed performance on the three
Table 1

Comparison of Performance of AD Patients and EC Subjects on Tests of Category Knowledge

<table>
<thead>
<tr>
<th>Test</th>
<th>AD (N = 18)</th>
<th>EC (N = 18)</th>
<th>$F(1, 34)$</th>
<th>$MS_e$</th>
<th>$p^*$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fluency&lt;sup&gt;a&lt;/sup&gt;</td>
<td></td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Animate</td>
<td>6.7</td>
<td>14.4</td>
<td></td>
<td></td>
<td>.01</td>
</tr>
<tr>
<td>Inanimate</td>
<td>7.8</td>
<td>14.8</td>
<td></td>
<td></td>
<td>.01</td>
</tr>
<tr>
<td>Group</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Category</td>
<td>4.3</td>
<td>2.1</td>
<td>&lt;.05</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Group × Category</td>
<td>1.1</td>
<td>2.1</td>
<td>.30</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ranking, HDE correct&lt;sup&gt;c&lt;/sup&gt;</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Animate</td>
<td>3.8</td>
<td>4.3</td>
<td></td>
<td></td>
<td>.08</td>
</tr>
<tr>
<td>Inanimate</td>
<td>4.8</td>
<td>5.3</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Group</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Category</td>
<td>3.3</td>
<td>1.4</td>
<td>&lt;.01</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Group × Category</td>
<td>16.6</td>
<td>1.1</td>
<td>&lt;.01</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ranking, entire sequence correct&lt;sup&gt;d&lt;/sup&gt;</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Animate</td>
<td>1.4</td>
<td>2.6</td>
<td></td>
<td></td>
<td>.09</td>
</tr>
<tr>
<td>Inanimate</td>
<td>2.7</td>
<td>2.6</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Group</td>
<td></td>
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<tr>
<td>Category</td>
<td>3.0</td>
<td>1.9</td>
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<tr>
<td>Group × Category</td>
<td>10.1</td>
<td>0.8</td>
<td>&lt;.01</td>
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<td></td>
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<tr>
<td>Category decision, dominance&lt;sup&gt;d&lt;/sup&gt;</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>HDE</td>
<td>918</td>
<td>772</td>
<td>106</td>
<td></td>
<td></td>
</tr>
<tr>
<td>LDE</td>
<td>973</td>
<td>837</td>
<td>115</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Group</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dominance</td>
<td>8.1</td>
<td>44,043.7</td>
<td>&lt;.01</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Group × Dominance</td>
<td>31.9</td>
<td>2,012.0</td>
<td>&lt;.01</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Category decision, word reading&lt;sup&gt;e&lt;/sup&gt;</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>HDE</td>
<td>608</td>
<td>550</td>
<td>85</td>
<td></td>
<td></td>
</tr>
<tr>
<td>LDE</td>
<td>569</td>
<td>551</td>
<td>90</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Group</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dominance</td>
<td>1.5</td>
<td>16,229.6</td>
<td>.22</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>1.9</td>
<td>3,313.0</td>
<td>.18</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note. AD = patients with Alzheimer's disease; EC = elderly control subjects; HDE = high dominance exemplar; LDE = low dominance exemplar. 
<sup>a</sup> Probability level, two-tailed.  
<sup>b</sup> Number of items produced.  
<sup>c</sup> Number correct of 6.  
<sup>d</sup> Reaction time in ms, 40 trials.  
<sup>e</sup> Reaction time in ms, 80 trials.

animate and three inanimate categories described in the fluency test results. Animate and inanimate categories were matched for mean word length and mean dominance ratings, measured as percentage of Battig and Montague's (1969) normative sample that provided that exemplar in response to the target category. Mean dominance rating for the animate categories was 60.2 for HDE and 4.8 for LDE; for the inanimate categories, 66.4 for HDE and 5.0 for LDE. Mean word length for the animate categories was 6.0 for HDE and 5.9 for LDE; for inanimate categories, 5.4 for HDE and 5.3 for LDE. The measure was number correct of six trials (two trials for each of animals, birds, etc.) and, as before, separate assessments were performed to evaluate success in ranking the HDE only and in ranking the entire three-item sequence. In the HDE assessment, there was no effect of subject group, but there was a main effect of category group, with the HDE on animate trials being more difficult to rank correctly than the HDE on inanimate trials. There was no Subject-Group × Category-Group interaction, indicating that AD patients were not more or less likely than EC subjects to have difficulty in ranking on animate versus inanimate trials. For the entire sequence, there was again no effect of subject group, but a main effect of category group: Entire sequences on animate trials were more difficult to rank than on inanimate trials. There was also a Subject-Group × Category-Group interaction; AD patients were more likely than EC subjects to make errors in ranking the entire three-item sequence on animate trials (Table 1).

Category Decision

**Dominance.** Results are for the 40 novel trials in which the correct response was "yes"; that is, trials in which the exemplar was in fact a member of the category that appeared in the question. The AD patients were slower to respond overall than the EC subjects. Both groups showed a normal dominance effect, with HDE correctly judged to be exemplars more quickly than LDE of the same category (Table 1). The size of the dominance effect did not differ for the two groups. For the AD patients, RT
on neither HDE nor LDE was correlated significantly with dementia severity, as measured with the BDS: HDE, r(16) = .36; LDE, r(16) = .25.

The pattern of performance by category was similar for the two groups: Categories that elicited relatively long (or short) RTs for the EC subjects were the same categories that elicited relatively long (or short) RTs for the AD patients, r(8) = .69, p < .05. Across categories, the AD patients' mean RT was 118.5% that of the EC subjects' mean, with a standard deviation of only 4.3 (range = 113%-126%), suggesting that the increased RT for the AD patients relative to EC subjects was highly consistent across the 10 categories.

Performance was compared on animate versus inanimate trials for 16 patients (the other 2 patients made errors resulting in insufficient data for some categories). Two-way analyses of variance (ANOVAs) indicated an effect of dominance (faster on HDE trials), F(1, 15) = 19.52, MS = 4471.4, p < .01, but no effect of category group (animate vs. inanimate), F = 0.04, MS = 7997.4. Mean RTs were as follows: HDE-animate, M = 872, SD = 218; HDE-inanimate, M = 952, SD = 206; LDE-animate, M = 950, SD = 204.

Accuracy was high for both groups. Five EC subjects made one or two errors over the 80 trials, for a group mean of 0.22 errors (SD = 0.54); 11 AD patients made up to three errors, for a group mean of 0.56 errors (SD = 0.73). Errors included false positives (nonmember judged to be a member) and false negatives (member judged to be a nonmember). The AD patients had a total of four false positives for HDE trials and one for LDE trials, and the EC subjects had two each for the HDE and LDE trials. The AD patients had a total of six false negatives for HDE trials and nine for LDE trials, and the EC subjects had one for HDE trials and three for LDE trials. The type of error (false positive vs. false negative) did not differ for the two subject groups, χ² (1, N = 28) = 0.65 (Yates correction for continuity). Accuracy of the AD patients was not correlated with dementia severity as measured with the BDS, r(16) = 0.19.

Word reading  Results are for all 80 novel trials. One patient with AD was not given the reading test because of time constraints. There was no effect of word group (those used for HDE trials vs. those used for LDE trials in the dominance task) or subject group on RT (Table 1), indicating that the observed dominance effect was not related to any differential ability to read HDE and LDE words. For the AD patients, RT was significantly correlated with dementia severity for HDE trials, r(15) = .64, p < .01, and for LDE trials, r = .50, p < .05. Accuracy was very high for both groups, with no EC subjects making an error, and 2 AD patients each making only one error in 80 trials.

Relation of Fluency and Category Decision Results

We performed a correlation between performance on the two retrieval tests, fluency and category decision, for the 10 categories assessed. For each subject group, those categories that elicited relatively long (or short) RTs on category decision were the same categories that elicited relatively few (or many) responses on fluency: AD patients, r(8) = .59, p < .06; EC subjects, r(8) = .67, p < .05. The results indicate that there is a relation between performance on the retrieval tasks of fluency and category decision, as seen in AD patients and in EC subjects.

Discussion

The results of the present study suggest that, for category knowledge in AD, retrieval deficits may be explained by a general factor that influences information processing, but not by disrupted organization or by a selective vulnerability of certain classes or categories of items.

Normal organization of category information is supported by the results on the fluency, ranking, and category decision tests. On the ranking test, patients with AD were as successful as EC subjects at ranking items in order of category typicality level, both for the most highly dominant item and for the entire
three-item sequence. This result contrasts with reported impaired performance of ranking of semantic associates in AD on an otherwise identical task (Grober et al., 1985), suggesting that associative and category information are differentially affected in AD.

On the category decision and fluency tests, AD patients showed the same pattern of performance as EC subjects. Both groups were faster to correctly judge high-dominant exemplars of target categories than low-dominant exemplars, although the AD group was slower overall. This result replicates that of Nebes et al. (1986). The high level of accuracy that we observed is similar to accuracy levels found in other studies of category decision in AD (Huff et al., 1986; Nebes et al., 1986). Further supporting the conclusion of normal organization of category knowledge is the observation that performance on the 10 assessed categories was strongly correlated for the two groups: The categories for which EC subjects' reaction times were relatively long (or short) were the same categories for which AD reaction times were relatively long (or short). This consistency in organization is underscored by the fact that the “slower” categories on the category decision task are the same categories for which subjects (EC subjects and AD patients) produced relatively few members on the fluency task and, likewise, the “faster” categories are those for which subjects produced a relatively large number of members. The normal pattern of performance is maintained in AD despite the patients' overall longer reaction times on category decision, and overall reduced output on fluency, relative to EC subjects.

Our results do not support the hypothesis that the semantic retrieval deficit of AD applies differentially to certain classes or categories of information. For 10 individual categories, the pattern of performance on the category decision test (as assessed by reaction time) and on verbal fluency (as assessed by items produced) was strikingly similar for the AD patients and EC subjects. We also found no differences in performance on these tests after grouping 6 individual categories to form the animate and inanimate classes. Post hoc analyses of the ranking (HDE only), category decision, and fluency data revealed no selective vulnerability of animate object information, relative to inanimate object information. These findings contrast with those of Silveri et al. (1991). We did, however, observe that AD patients may have selective difficulty ranking an entire sequence of three exemplars of animate categories, relative to inanimate categories. Further studies incorporating the animate-inanimate distinction into the experimental design may resolve the discrepancy in results. Finally, there was no special vulnerability of low-dominant category information in AD. Although our pilot study of eight patients with AD (Cronin-Golomb, Keane, Corkin, & Growdon, 1989) had suggested that dementia severity was correlated with performance on the category decision task for low-dominant exemplars specifically, this relation did not hold in the present larger study. The results accord with the finding by Ober et al. (1986) that AD patients did not have special difficulty in retrieving low-dominant category exemplars on a fluency task, and with the report by Nebes et al. (1986) that AD patients show normal slowing of reaction time in response to low-dominant relative to high-dominant exemplars on a category decision task. Although it is possible that some patients with AD suffer item-specific information loss (Huff et al., 1986, 1988), our results suggest that loss of differentially impaired retrievability that is category- or class-specific is not an important contributor to deficits in retrieval of category knowledge in AD.

Evidence for a general factor or factors that limit information retrieval in AD comes from the results on the fluency and category decision tests. Although AD patients and EC subjects differed in absolute level of performance on these tests, the pattern of performance was the same for the two groups. On the fluency test, the AD patients produced, on average, 51% of the number of responses produced by EC subjects across all 10 categories, with a range of 41% to 61% for individual categories. On the category decision test, the mean reaction time across all 10 categories for the AD patients was 1.19 times that of EC subjects, with a very small range of 1.13 to 1.26 for individual categories. The narrow range of performance by category on the fluency and category decision tests, taken together with the high correlation in performance on these two tests by the AD patients as well as the EC subjects, suggests that some common limiting factor or factors may underlie performance on these tests.

One candidate for a general factor limiting information retrieval is processing speed, either exerting its effects directly or influencing later processing operations in a nonlinear fashion. Salthouse (1985a, chap. 10) has pointed out in regard to normal aging that a slower rate of operations could have any one or a combination of the following results: loss of effectiveness of certain problem-solving strategies; decreased opportunity to develop and refine optimal strategies; or increased frustration and anxiety about ineffective performance, which in turn would lead to deficient performance. In the present study of AD patients, slowed processing was suggested by good accuracy but long reaction times relative to EC subjects on the category decision test. On the word reading test, reaction time was correlated with dementia severity. The slowing (or other general factor) appears to be constant in the within-category domain; that is, the difference between performance of AD patients and EC subjects on the fluency and category decision tests did not depend on the specific category assessed. In domains other than category knowledge, slowing may occur to different extents in different tasks (Nebes & Madden, 1988).

In the case of the effect of AD on fluency, it is necessary to postulate a process interaction, rather than decreased processing speed alone, to explain two observations. First, it is a common finding that patients do not perform poorly on fluency tests because they run out of time; in fact, patients tend to produce most of their responses early in the prescribed time period, and often produce no new responses toward the end of the time period. Second, on the "supermarket" fluency task, AD patients do not simply produce fewer items than control subjects, but rather produce fewer subcategories of items and fewer items per subcategory (Martin & Fedio, 1983; Ober et al., 1986). These observations suggest that other factors besides shear speed of processing are involved in information retrieval on fluency tasks. One related factor may be the effort needed for processing, commensurate with task difficulty, as suggested by Bayles et al. (1991).

The notion that retrieval deficits for category knowledge may stem in part from reductions in processing speed is reasonable.
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in light of known neuropathological changes in AD. AD is associated with extensive loss of and degenerative changes in neurons in several brain regions (Arnold, Hyman, Flory, Damasio, & Van Hoesen, 1991; Terry, 1980). In the neocortex, neurons that do not die nevertheless suffer dendritic loss, especially loss of the horizontally oriented dendrites (e.g., basilar, oblique, and apical arch branches; Scheibel & Scheibel, 1975). Scheibel and Scheibel have pointed out that progressive, selective loss of the horizontal masses must interrupt progressively larger numbers of intracortical circuits, and cause the diminishment of central program storage area. If retrieval deficits in normal aging result directly or indirectly from increased processing time (e.g., Birren's cycle-time hypothesis, described by Salthouse, 1985b), and increased processing time presumably follows from neuronal loss (especially the loss of the horizontal dendrites), then the excessive neuronal loss that characterizes AD would be expected to compound the processing time increase of normal aging and lead to more severe retrieval deficits.

Research on patients with damage to temporolimbic structures has suggested that retrieval deficits may be specific for particular semantic categories. There are several reports of patients with aphasia or visual agnosia of various etiologies, often involving left temporal structures, who showed selective deficits in retrieval of information from specific categories. Such deficits, evidenced by inability to name, to match to sample (words or pictures), or otherwise to exhibit knowledge of items belonging to those categories, are believed by some researchers to support category-specific neural organization of semantic knowledge (e.g., Hart, Berndt, & Caramazza, 1985; Sartori & Job, 1988; Warrington, 1975; Warrington & McCarthy, 1983). There is some debate over whether retrieval deficits apply to categories in the traditional sense (e.g., animals, furniture, vehicles), or rather to particular kinds of information, the attributes of which span several traditional categories. Possible dichotomous attributes that have been proposed include animate versus inanimate (McCarthy & Warrington, 1988), functional versus sensory (Warrington & McCarthy, 1983, 1987), basic-level versus subordinate (Bub, Black, Hampson, & Kertesz, 1988), and generic versus unique (Ellis, Young, & Critchley, 1989; Goldstein, 1963). In the present study of AD patients, who typically have severe damage to temporolimbic structures (Arnold et al., 1991), we found normal organization of traditional categories at the superordinate level. In addition, although we did not design this study with the purpose of identifying selective disruption pertaining to knowledge of specific categories in AD, post hoc analysis of the category decision and fluency data revealed no obvious general disruption of animate (vs. inanimate) categories, such as was recently reported to occur in AD (Silveri et al., 1991). We conclude that temporolimbic lesions characteristic of AD do not necessarily lead to category-specific dysfunction, although such dysfunction may occur with temporolimbic damage of other etiologies.

In summary, our results indicate that category information is organized normally in AD, even in moderately to severely demented patients; that there is no selective vulnerability of particular classes or categories of information that would account for impaired retrieval of category information; and that such retrieval deficits are best explained by a constant general factor or factors that influence information processing across all categories. Although reduced processing speed is a likely candidate for such a factor, it is probably in itself insufficient to account for the results of this and other studies, which may require the supposition of an additional contributing factor or factors, such as task difficulty. The exact nature of the general limiting factors and whether they are specific to the domain of semantic memory are subjects for further research.

References

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1993 APA Convention "Call for Programs"

The "Call for Programs" for the 1993 APA annual convention appears in the October issue of the APA Monitor. The 1993 convention will be held in Toronto, Ontario, Canada, from August 20 through August 24. Deadline for submission of program and presentation proposals is December 10, 1992. Additional copies of the "Call" are available from the APA Convention Office, effective in October. As a reminder, agreement to participate in the APA convention is now presumed to convey permission for the presentation to be audiotaped if selected for taping. Any speaker or participant who does not wish his or her presentation to be audiotaped must notify the person submitting the program either at the time the invitation is extended or prior to the December 10 deadline for proposal submission.