Semantic Memory in Alzheimer’s Disease: Representativeness, Ontologic Category, and Material

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Alzheimer’s disease (AD) patients with semantic memory difficulty and AD patients with relatively preserved semantic memory named pictures and judged the category membership of words and pictures of natural kinds and manufactured artifacts that varied in their representativeness. Only semantically impaired patients were insensitive to representativeness in their category judgments. AD subgroup judgments did not differ for natural kinds compared to manufactured artifacts nor for words compared to pictures. AD subgroup differences could not be explained by dementia severity, memory, reading, and visuo-perception. The similarity process for relating coordinate members of a taxonomic category contributes to the normal appreciation of word and picture meaning, and this process is compromised in AD patients with semantic difficulty.

Semantic memory is the long-term mental representation of the meaning underlying verbal and nonverbal representations of a concept (Jackendoff, 1983; Tulving, 1972). Many reports over the past two decades have observed deficits on tasks requiring semantic memory in patients with probable Alzheimer’s disease (AD), such as naming and judging the semantic category of a test object (Bayles, Tomoeda, & Trosset, 1990; Chertkow & Bub, 1990; Hodges, Salmon, & Butters, 1992; Huff, Corkin, & Growdon, 1986). The semantic deficit has been attributed to factors such as loss of semantic knowledge (Chertkow, Bub, & Caplan, 1992; Montanes, Goldblum, & Boller, 1995; Silveri, Daniele, Giustolisi, & Gainotti, 1991) or difficulty with the processes underlying the appreciation of word or picture meaning (Chan, Butters, Paulsen, et al., 1993; Chan, Butters, Salmon, & McGuire, 1993; Grober, Buschke, Kwas, & Fuld, 1985; Nebes, Martin, & Horn, 1984; Ober, Shenaut, Jagust, & Stillman, 1991). However, others have challenged the claim that difficulties on tasks such as naming are due to impaired semantic memory (Biassou et al., 1995; Cronin-Golomb et al., 1991; Massman et al., 1993; Mendez, Mendez, Martin, Smyth, & Whitehouse, 1990). One potential reason for these differing results may be that most studies have examined unselected series of AD patients. AD is a clinically heterogeneous disorder (Grady et al., 1990; Haxby, Grady, Koss, & Horwitz, 1988; Schwartz, 1990) where subgroups of AD patients may have subtle but important differences in their pattern of cognitive difficulty. For example, only half of AD patients may have compromised semantic memory (Grossman et al., 1996). Moreover, some aspects of the semantic deficit in AD may be confounded by other cognitive difficulties that are present in these patients. Recent studies have related a semantic memory deficit to episodic memory limitations (Grossman, Mickanin, Onishi, Robinson, & D’Esposito, in press; Snowden, Griffiths, & Neary, 1996) or to difficulty appreciating perceptual attributes of visual representations of object concepts (Montanes, Goldblum, & Boller, 1996). To examine the basis for semantic difficulty in AD more carefully, this report investigated semantic memory in a subgroup of AD patients with compromised semantic memory, contrasting these patients with a carefully matched subgroup of AD patients having relatively preserved semantic memory.

Briefly, our model of semantic memory includes a material-neutral database of conceptual information. This information may be organized taxonomically, that is, according to categories of knowledge such as FRUIT and FURNITURE (we use capitals to indicate concepts). There are several ways in which information may be selected from this database (Katz & Fodor, 1963; Komatsu, 1992; Smith, 1995), and we focus in the present study on the similarity process that compares a test item with an ideal exemplar or with remembered instances of the desired target (Rips, 1989; Smith & Sloman, 1994). The retrieved information can then be processed further in a modality- and material-specific buffer.

Several studies have found evidence to support the hypothesis that the knowledge represented in semantic memory may be degraded in AD. For example, a category-specific deficit has been observed in AD, where patients have greater difficulty with natural kinds than with manufactured artifacts on tasks such as confrontation naming and word–picture matching that use line drawings as stimuli.
(Chertkow et al., 1992; Montanes et al., 1995; Silveri et al., 1991). It is noteworthy that appearance features appear to be more crucial for recognizing natural kinds than manufactured artifacts (Flores d’Arcais & Schreuder, 1987; Flores d’Arcais, Schreuder, & Glazenburg, 1985). In this context, the category-specific impairment in AD may be due in part to relative difficulty appreciating the appearance features of natural kinds (Farah & McClelland, 1991; Warrington & McCarthy, 1987; Warrington & Shallice, 1984). In AD, for example, it has been observed that the category-specific impairment dissolves with the use of perceptually enriched color picture stimuli (Montanes et al., 1996). However, other studies have failed to replicate these category-specific findings (Cronin-Golomb, Keane, Kokolis, Corkin, & Growdon, 1992; Mickanin, Grossman, Onishi, Auriacombe, & Clark, 1994; Tippett, Grossman, & Farah, 1996). Another study has found that function attributes are more difficult than appearance attributes in AD (Johnson & Hermann, 1995). It is thus unclear whether the information represented in semantic memory is degraded in AD. In the present study, we investigated the integrity of knowledge in semantic memory by asking AD patients to name and judge natural kinds and manufactured artifacts. Moreover, we assessed the role of perceptual attributes in category-specific knowledge by administering the stimuli as words and color pictures.

An alternative approach to compromised semantic memory in AD comes from investigations that have studied the processes implicated in semantic memory, such as information identification and retrieval. To examine the similarity approach to semantic processing, studies have manipulated the representativeness of test items in comparison to a target concept. Many investigators have observed response patterns in healthy adults that are graded according to the typicality of a test item: A highly representative exemplar such as peach is likely to be recognized more accurately and more rapidly as FRUIT than a less representative but an equally frequent exemplar like prune, for example (Rosch, 1975; Rosch & Mervis, 1975). Alterations in this similarity process have been observed in AD, suggesting a semantic memory impairment. For example, AD patients have found it difficult to identify the most representative attributes of an object (Grober et al., 1985) and have violated the representativeness relationship between category exemplars on category naming and multidimensional scaling tasks (Chan, Butters, Paulsen, et al., 1993; Chan, Butters, Salmon, et al., 1993). However, other investigators have emphasized normal response patterns on word association and category membership judgment tasks when the representativeness of an exemplar is manipulated (Cronin-Golomb et al., 1992; Johnson, Hermann, & Bonilla, 1995; Smith, Faust, Beeman, Kennedy, & Perry, 1995). In the present study, we investigated whether semantically impaired AD patients differ from semantically preserved AD patients in their sensitivity to representativeness.

One factor contributing to the disparate findings described previously may be that mixed groups of AD patients were examined on these tasks. AD appears to result in subgroups of patients that are disproportionately impaired with specific aspects of cognition (Grady et al., 1990; Haxby et al., 1988; Schwartz, 1990). For example, based on an evaluation of semantic category membership judgments, it is estimated that about 55% of AD patients have a semantic memory impairment (Grossman et al., 1996). This heterogeneity may be related in part to the varied patterns of reduced regional cerebral metabolic activity that are seen in AD (Grady et al., 1990; Haxby et al., 1988). Differences in left posterior peri-Sylvian activity appear to distinguish in part between semantically impaired and semantically preserved AD patients (Grossman, White-Devine, et al., 1997). Group studies averaging across subgroups of semantically impaired AD patients and AD patients with preserved semantic memory may not provide a clear picture of compromised semantic memory. Researchers in several previous studies examined a subgroup of semantically impaired AD patients (Chertkow & Bub, 1990; Chertkow et al., 1992), but they did not control for the presence of a dementia or specific features of a dementing syndrome in comparisons with AD patients having relatively preserved semantic memory. For example, recent work has begun to emphasize the important relationship between impaired semantic memory and an episodic memory deficit that is the sine qua non of dementia (Grossman, Mickanin, et al., in press; Snowden et al., 1996). Limitations in episodic memory thus may have an important impact on semantic memory, and the ability to attribute an effect in AD to semantic memory is confounded by the fact that the control group is neurologically intact and differs from the semantically impaired AD group in both semantic memory and episodic memory. Similarly, some AD patients may have visual deficits that can confound the interpretation of naming and category judgment measures used to assess semantic memory (Cronin-Golomb et al., 1991; Levine, Lee, & Fisher, 1993; Massman et al., 1993; Mendez et al., 1990). In the present report, we addressed these issues by comparing carefully matched subgroups of semantically impaired and semantically preserved AD patients.

Method

Participants

We assessed 16 right-handed native English speakers who were diagnosed with probable dementia of the Alzheimer's type, according to National Institute of Neurological and Communication Disorders and Stroke and Alzheimer's Disease and Related Disorders Association (NINCDS—ADRD Association) criteria (McKhann et al., 1984). These patients were recruited from the Cognitive Neurology clinic at the Hospital of the University of Pennsylvania. AD patients were screened for the severity of dementia, and participation was restricted to mildly and moderately impaired patients with a Mini-Mental State Examination (MMSE; Folstein, Folstein, & McHugh, 1975) score ≥11. We excluded patients with other causes of dementia such as vascular disease, psychiatric disorders such as primary depression or psychosis, medical illnesses or metabolic conditions that may have resulted in encephalopathy, infectious diseases that may have resulted in progressive intellectual decline, or other neurologic conditions affecting the central nervous system that may have an impact on cognitive performance. None of the participants were taking sedating medications at the time of testing.

Several tests were administered to ensure that the patient subgroups were matched for specific cognitive features that are
often compromised in AD. The patients were assessed with a measure of short-term memory—the repetition of a sequence of digits (Wechsler, 1987); with a 10-word list-learning task that involved three learning trials (we compared patients using the difference between the number of words reproduced for Trial 3 and Trial 1), a free-recall period 2 min following presentation, and a recognition session immediately following free recall where 50% of the 20 stimuli were targets from the original list (Welsh, Butters, Hughes, Mohs, & Heyman, 1991); and with a measure of visual processing on an 11-point scale—the construction of four geometric designs (Welsh, Butters, Hughes, Mohs, & Heyman, 1992). One patient was not assessed for list learning. The AD patients also were able to read on average 97% of the verbal stimuli.

The AD patients were compared to 14 right-handed, healthy, native English speakers who were age matched, t(28) = 1.64, ns, and education matched, t(28) = 0.27, ns, with the AD patients. Clinical and demographic features of the control participants and AD patients are summarized in Table 1.

**Materials**

Participants were asked to perform two related tasks, confrontation naming and category membership judgment. The two tasks were always given in the same order—naming followed by judgments—to avoid exposing patients to a picture–name pair prior to being asked to retrieve the name of a picture spontaneously.

**Confrontation naming.** Patients were shown color photographs one at a time, and were asked to name them. The targets for confrontation naming were selected from four different categories, that is, two natural kinds (FRUIT, VEGETABLE) and two manufactured artifacts (TOOL, FURNITURE). There were 18 test items from each of the represented categories, and the names were divided into roughly equal sets of stimuli that are high, moderate, and low in their representativeness (Rosch, 1975). An analysis of variance (ANOVA) with a Category (4) X Level of Representativeness (3) design demonstrated that the names were matched for frequency of occurrence (Francis & Kucera, 1982) across categories, F(3, 68) = 0.95, ns; and representativeness levels, F(2, 69) = 0.28, ns. To ensure similarity of the stimuli across categories, we took color photographs of the test items displayed from a prototypical perspective and, whenever possible, against a homogeneous background. Each 4 × 6-in. (~10 × 15 cm) photo was centrally mounted on a 5 × 8-in. (~12.5 × 20 cm) white file card. The color photographs were presented in a fixed random order. The confrontation naming protocol was recorded on audiotape for later analysis. Confrontation naming was scored for accuracy, and errors were scored for error type. These included semantic errors (related to the target semantically as superordinate, coordinate, or subordinate), phonemic errors (sounding similar to the target item), and errors unrelated semantically and phonologically. Two judges independently scored all responses, and interrater agreement was 95%. Discrepancies were resolved through consensus discussion.

**Category membership judgment.** The category membership judgment task evaluated the participants’ decisions about the superordinate category membership of a presented stimulus. Thus, participants were asked “Is this an X?”; where X corresponded to the name of the superordinate category, and the participants responded dichotomously “yes” or “no.” The target stimuli included the same items used in the confrontation-naming task. A color photograph stimulus set was presented for judgment that corresponded to the 72 photographic items used in the confrontation-naming task. In addition, a word stimulus set was presented, where the words were printed in large, black, lowercase lettering on a 5 × 8-in. (~12.5 × 20 cm) white background. For each of the four target superordinate categories (FRUIT, VEGETABLE, TOOL, FURNITURE), there were 18 targets (divided into roughly equal numbers of high, moderate, and low representativeness stimuli) and 12 foils. The foils were items that could not be properly categorized as members of the target category, according to published criteria (Rosch, 1975; Battig & Montague, 1969). Six of the foils for each category were semantically related, because they were taken from a different superordinate category that overlaps the target category in its meaning (e.g., for the target FRUIT, a semantically related foil could be another type of cultivated food such as lettuce). Six of the foils for each category were semantically unrelated, because they were drawn from a different superordinate category that had little overlap with the target category in their meaning (e.g., for the target FRUIT, a semantically unrelated foil could be an artifact such as chair). The targets and foils were matched for frequency of occurrence across categories. The stimuli were presented in a fashion blocked by superordinate category and by material (word vs. picture), and stimuli were presented in a fixed random order within each block. The blocks of stimuli were presented in a random order with the proviso that picture and word blocks for the same superordinate category were not presented consecutively. The participants’ answers were scored as either

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**Table 1**

**Demographic and Clinical Features of Controls and AD Patients**

<table>
<thead>
<tr>
<th>Feature</th>
<th>Controls (n = 14)</th>
<th>Alzheimer’s patients</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>M</td>
<td>SD</td>
</tr>
<tr>
<td>Age (years)</td>
<td>69.7</td>
<td>9.6</td>
</tr>
<tr>
<td>Education (years)</td>
<td>15.4</td>
<td>2.8</td>
</tr>
<tr>
<td>Disease duration (years)</td>
<td>3.3</td>
<td>3.6</td>
</tr>
<tr>
<td>Disease severity (MMSE)</td>
<td>29.1</td>
<td>1.0</td>
</tr>
<tr>
<td>Digit span forward</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>List learning: Trial 3 – Trial 1</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>List learning: Free recall</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>List learning: Recognition</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Visual construction</td>
<td>—</td>
<td>—</td>
</tr>
</tbody>
</table>

**Note.** The number of males and females for each group is as follows: controls, 10 males, 4 females; total Alzheimer’s disease (AD) patients, 10 males, 6 females; AD—semantic preserved, 5 males, 1 female; AD—semantic impaired, 5 males, 5 females. MMSE = Mini-Mental State Examination.
correct or incorrect. In addition to overall accuracy, we noted the distribution of incorrect judgments (their false rejection of high, moderate, or low representative targets, their false acceptance of semantically related or semantically unrelated foils, and their false rejection of words or pictures that are natural kinds or manufactured artifacts).

**Statistical Analysis**

The tasks contained slightly different numbers of high, moderate, and low representative items across categories, so the raw numbers of correct responses were converted to percentages of correct responses for purposes of analysis. Membership in an AD patient subgroup was based on the a priori reasoning that AD patients with a semantic memory impairment are likely to have difficulty on both confrontation-naming and category membership judgment tasks. In practice, the same result would have emerged if we had based our classification only on category membership judgments. Specifically, we used discriminant analyses for confrontation naming and for category membership judgments, each significant at least at the $F > 4.00$ level, to partition the entire population of controls and AD patients into two groups. Based on the results of these discriminant analyses, all (100%) of the control participants were placed into one group. Six (37.5%) of the AD patients were classified with the controls. Four of these AD patients did not differ statistically from controls in their confrontation naming or their category membership judgments, but 2 of these AD patients differed from controls only in their confrontation naming. This subgroup of AD patients was likely to have relatively preserved semantic memory. By comparison, a subgroup of 10 (62.5%) AD patients was classified differently from controls for both their confrontation naming and their category membership judgments. Because confrontation naming and category membership judgment were both relatively compromised, these AD patients were more likely to have impaired semantic memory. As summarized in Table 1, AD patients thought to have semantic memory difficulty did not differ from the remaining AD patients with relatively preserved semantic memory in terms of age, education, overall dementia severity as measured by the MMSE, or disease duration. The AD subgroups did not differ in their digit span, $t(14) = 1.52, ns$; their learning performance on a list-learning task, $t(13) = 0.07, ns$; their free recall of these words 2 min after presentation, $t(13) = 0.14, ns$; their recognition of the stimulus words, $t(13) = 0.15, ns$; or their visual performance, $t(14) = 0.71, ns$. These findings emphasize that differences in the semantic processing of these AD subgroups cannot be attributed easily to the presence of a dementia or cognitive features frequently associated with a dementia. Qualitative analyses of naming and judgment profiles for representativeness, ontologic category, and material were evaluated in AD patient subgroups using ANOVAs and $t$ tests.

**Results**

**Confrontation Naming**

Assessment of confrontation-naming accuracy using a multivariate ANOVA with a 3 (group—controls, semantically preserved AD patients, semantically impaired AD patients) $\times 2$ (category—natural kinds, manufactured artifacts) $\times 3$ (representativeness—high, moderate, low) design revealed a significant main effect for group, $F(2, 27) = 29.97, p < .001$. Controls were accurate for 90.67% ($\pm 5.2$) of their confrontation-naming trials, AD patients with relatively preserved semantic memory were accurate for 74.77% ($\pm 16.1$) of their confrontation-naming trials, and AD patients with a semantic memory impairment were accurate for 38.75% ($\pm 25.3$) of their confrontation-naming trials. Pairwise comparisons with $t$ tests demonstrated that these three groups differed from each other at least at the $p < .005$ level.

We also found significant main effects for representativeness, $F(2, 54) = 20.67, p < .001$, and category, $F(1, 27) = 8.11, p < .01$, as well as significant interaction effects for Group $\times$ Representativeness, $F(4, 54) = 3.03, p < .05$, and Group $\times$ Representativeness $\times$ Category, $F(4, 54) = 4.31, p < .005$. In general, semantically impaired AD patients were significantly worse than semantically preserved AD patients and controls for naming every type of stimulus, as summarized in Table 2. Interaction effects were due to some overlap in naming accuracy for controls and semantically preserved AD patients. The main effect for representativeness is reflected by the within-group finding that AD patients as a whole have more difficulty naming moderately representative pictures than highly representative pictures, $t(15) = 4.63, p < .001$, and more difficulty with moderately representative pictures than low representative pictures, $t(15) = 3.45, p < .005$, paralleling the pattern of relative naming accuracy seen in controls. The Group $\times$ Representativeness interaction effect was investigated with pairwise comparisons of groups using $t$ tests. These revealed that the semantically impaired AD patients differ from the semantically preserved AD patients and controls in naming accuracy at each level of representativeness at least at the $p < .01$

<table>
<thead>
<tr>
<th>Stimuli</th>
<th>Controls</th>
<th>AD patients</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$M$</td>
<td>$SD$</td>
</tr>
<tr>
<td><strong>Representativeness</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>High</td>
<td>94.9</td>
<td>5.7</td>
</tr>
<tr>
<td>Moderate</td>
<td>88.2</td>
<td>7.1</td>
</tr>
<tr>
<td>Low</td>
<td>88.8</td>
<td>8.1</td>
</tr>
<tr>
<td><strong>Category</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Natural kinds</td>
<td>89.9</td>
<td>7.2</td>
</tr>
<tr>
<td>Manufactured artifacts</td>
<td>91.2</td>
<td>6.3</td>
</tr>
</tbody>
</table>

*Note.* AD = Alzheimer's disease.
level. Semantically preserved AD patients also differed from controls at naming high and moderate representativeness stimuli at least at the $p < .05$ level, but these groups did not differ in their naming of low representativeness stimuli. The main effect for category is reflected by the within-group finding that AD patients as a whole encountered greater difficulty naming natural kinds than manufactured artifacts, $t(16) = 2.78, p < .01$, again paralleling the pattern of relative naming accuracy seen in controls. The Group $\times$ Representativeness $\times$ Category interaction effect was investigated with pairwise comparisons of group for representativeness levels across natural kind and manufactured categories. These demonstrated that semantically impaired AD patients are significantly worse than semantically preserved AD patients and controls at naming all of these types of items at least at the $p < .01$ level. Semantically preserved AD patients differed from the controls in their naming of these types of stimuli at least at the $p < .05$ level, except for their naming of low representative natural kind and manufactured stimuli and high representativeness manufactured stimuli.

In sum, patterns of naming differences between controls and subgroups of AD patients are difficult to interpret because of the many ways in which AD patients differ from controls. When we compared naming performance in AD subgroups matched for overall dementia severity, anterograde memory, short-term memory, and visuospatial functioning, however, we did not find any effects that were specific for the subgroup of AD patients thought to have a semantic memory deficit. Instead, we observed a groupwide deficit in AD for a particular ontic category (natural kinds $<$ manufactured artifacts) and a pattern of impaired naming that does not obey an order of difficulty corresponding to representativeness (moderate representativeness $<$ high $=$ low). These findings paralleled that pattern of relative naming accuracy seen in controls.

An evaluation of semantically related substitution errors during confrontation naming with a multivariate ANOVA using a $3$ (group) $\times$ $2$ (category) $\times$ $3$ (representativeness) design revealed significant main effects for group, $F(2, 27) = 12.32, p < .001$, category, $F(1, 27) = 10.29, p < .001$, and representativeness, $F(2, 54) = 5.40, p < .007$. There were no significant interaction effects. Semantic substitution errors were produced for $22.8\% (\pm 11.1)$ of the responses of AD patients with impaired semantic memory. This differed significantly from AD patients with relatively preserved semantic memory, $11.8\% (\pm 7.6), t(14) = 2.13, p < .05$, and from controls, $7.4\% (\pm 4.2), t(22) = 4.88, p < .001$. However, semantically preserved AD patients did not differ from controls in the proportion of their semantically related naming errors, $t(18) = 1.81, ns$. The pattern of greater semantic substitutions in the semantically impaired AD subgroup is consistent with our hypothesis that these AD patients are more likely to have a semantic memory impairment.

**Category Membership Judgments**

A multivariate ANOVA with a $3$ (group) $\times$ $2$ (category) $\times$ $3$ (representativeness) $\times$ $2$ (material—words, pictures) design did not reveal a significant main effect for group. Because of our a priori hypotheses, we performed pairwise comparisons of overall category membership judgments across groups. These revealed significantly worse performance in AD patients likely to have a semantic memory impairment (accuracy = $76.6\% (\pm 9.5)$) compared to AD patients with relatively preserved semantic memory (accuracy = $90.6\% (\pm 2.5)$), $t(14) = 3.49, p < .004$, and controls (accuracy = $92.5\% (\pm 3.2)$), $t(22) = 5.87, p < .001$, but we did not observe a difference between controls and semantically preserved AD patients, $t(18) = 1.31, ns$.

The ANOVA evaluating category judgment performance revealed a significant main effect for representativeness, $F(2, 54) = 73.19, p < .001$, and a significant interaction effect for Group $\times$ Representativeness, $F(4, 54) = 10.98, p < .001$. Figure 1 illustrates the judgment patterns of the groups for representativeness. Evaluation of the semantically impaired AD subgroup revealed a category membership judgment pattern that is relatively insensitive to representativeness. This subgroup failed to differ in judgments of high and moderate representative stimuli or judgments of moderate and low representative stimuli, according to $t$ tests. Moreover, there was no correlation between the level of representativeness and category judgment accuracy as shown by a Spearman rank correlation $r(28) = 0.250, ns$. The AD patient subgroup with relatively preserved semantic memory, by comparison, revealed a category judgment pattern that is sensitive to representativeness. They exhibited greater judgment accuracy for highly representative stimuli than for moderately representative stimuli, $t(5) = 2.55, p < .05$, and greater judgment accuracy for the moderately representative stimuli than for the low representative stimuli, $t(5) = 10.11, p < .001$. This paralleled the judgment performance of controls. Moreover, category judgment accuracy correlated with representativeness in the semantically preserved sub-

![Figure 1](image-url)
group, \(s(18) = 0.845, p < .001\). We compared the judgment-representativeness correlation slopes of the two AD patient subgroups and found a significant difference, \(z = 1.65, p < .05\) (one-tailed). Analysis of individual AD patient profiles revealed that 5 (83.3%) of the 6 semantically preserved AD patients obeyed a normal ordering of representativeness in their category membership judgments, but only 5 (50.0%) of the 10 semantically impaired AD patients showed such a normal ordering of representativeness. Taken together, these findings indicate that AD patients with impaired semantic memory are distinguished from AD patients with relatively preserved semantic memory, because only the former subgroup is insensitive to the representativeness of stimuli during a category membership judgment task.

It is noteworthy that there were no significant effects for judgments of different ontologic categories. Analyses of individual AD patient profiles indicated that 2 (33.3%) of the 6 semantically preserved patients had more difficulty judging the category membership of natural kinds than of manufactured artifacts, whereas 4 (40.0%) of the 10 semantically impaired AD patients were more impaired judging natural kinds than artifacts, proportions that do not differ statistically. The ANOVA did not reveal a significant main effect for material or a significant Group \(\times\) Material interaction effect, suggesting that any difference in material-specific meaning representations or in reading or visuo-perceptual processing was unlikely to contribute significantly to the category membership judgment deficit of semantically impaired patients.

We examined category judgment errors using an ANOVA with a 3 (group) \(\times\) 2 (relatedness—related, unrelated) design. This revealed significant main effects for group, \(F(2, 27) = 28.24, p < .001\), and relatedness, \(F(2, 27) = 19.39, p < .001\), and a significant Group \(\times\) Relatedness interaction effect, \(F(2, 27) = 4.04, p < .03\). As can be seen in Figure 2, the semantically impaired AD subgroup was significantly less accurate than the AD subgroup with relatively preserved semantic memory, \(r(14) = 4.57, p < .001\), and less accurate than the controls, \(r(22) = 7.65, p < .001\), in judgments of semantically related foils, although the AD subgroups did not differ statistically in their judgments of semantically unrelated foils, \(r(14) = 2.10, n.s.\). These findings indicate that AD patients with a semantic memory impairment differ from semantically preserved AD patients in their disproportionate difficulty judging the category membership of foils related semantically to the target category.

### Discussion

Analyses of AD patients' performance on measures of confrontation naming and category membership judgments have reached divergent conclusions regarding the basis for observed impairments. It has been demonstrated in several clinical and imaging studies that AD is a heterogeneous disorder. These patients differ in the occurrence of compromised semantic memory and in the anatomic distribution of their functional cerebral defect (Grady et al., 1990; Grossman et al., 1996; Haxby et al., 1988). We partitioned AD patients into subgroups that have a relative semantic impairment or that have relatively preserved semantic memory based on their overall performance on confrontation naming and category membership judgment tasks, and we then examined qualitative differences in the performance of these subgroups. These AD patient subgroups were otherwise carefully matched for demographic characteristics as well as for cognitive features, such as overall dementia severity, anterograde memory, short-term memory, reading, and visuo-perceptual performance, so differences between these subgroups could not be attributed easily to other cognitive limitations seen in a dementing syndrome. AD subgroup comparisons for confrontation naming confirmed our approach to subgroup partitioning. The semantically impaired AD patients produced significantly more semantic substitutions than AD patients with relatively preserved semantic memory. However, we did not observe differences in naming between subgroups in terms of representativeness or ontologic category. We suspect that confrontation naming was less successful at identifying subtle differences related to semantic difficulty because of the overwhelming effect of impaired lexical retrieval in AD compared to more subtle differences that can be due to a semantic deficit (Bayles et al., 1990; Biassou et al., 1995; Martin & Fedio, 1983). Consistent with this hypothesis is the finding that semantically preserved AD patients differed from controls in their overall naming accuracy, a difference that could not be attributed to a semantic limitation.

When the effect of lexical retrieval was minimized by the administration of a category membership judgment task, qualitative differences between AD patient subgroups emerged. Specifically, AD patients with a semantic memory impairment did not respect representativeness in their category membership judgments, failing to distinguish between
high, moderate, and low representative exemplars of a superordinate category. By comparison, AD patients with relatively preserved semantic memory demonstrated a normal pattern of sensitivity to representativeness, including typicality-sensitive ordering of accuracy for judgments of high, moderate, and low representative exemplars. We also observed that only semantically impaired AD patients have difficulty judging the category membership of semantically related foils. Differences such as these cannot be attributed to discrepancies in the overall level of dementia, disease duration, age, education, visual functioning, reading, anterograde memory, or short-term memory, because the two AD subgroups were matched for these characteristics. Taken together, this pattern of findings is consistent with the hypothesis that the processing of the relationships between coordinates in a taxonomic category are compromised in semantically impaired AD patients.

Other investigators also have reported an abnormal ordering of representativeness in AD patients’ performance. For example, AD patients asked to judge the importance of a test word in relation to a superordinate target word did not exhibit an ordering of lexical associations graded according to typicality (Grober et al., 1985). Neither performance on a triadic comparison procedure (Chan, Butters, Salmon, et al., 1993) nor the response pattern on a category naming fluency task (Chan, Butters, Paulsen, et al., 1993) was sensitive to representativeness. Evidence from the priming literature also suggests a pattern of deranged semantic relations in AD. Thus, AD patients have demonstrated significant priming for high-frequency lexical associates such as “cream—cheese,” but not for low-frequency associates that are otherwise semantically related because of their mutual membership in a taxonomic category such as “peach—kiwi” (Glosser & Friedman, 1991; Glosser, Friedman, Grugan, Lee, & Grossman, in press).

Other studies have demonstrated a normal ordering of representativeness in AD (Cronin-Golomb et al., 1992; Johnson et al., 1995; Nebes, Boller, & Holland, 1986; Nebes & Brady, 1990). Semantic priming studies in AD have also shown that a highly representative stimulus appears to be associated more rapidly with a superordinate than with a less representative stimulus (Nebes et al., 1986; Ober et al., 1991). Discrepant results across studies may have been due in part to the participation of different proportions of AD patients with semantic difficulty, resulting in groupwide performance patterns that differ in subtle but important fashions. The observations of the present report emphasize the importance of studying well-defined subgroups of AD patients during assessments of semantic memory.

What could account for the pattern of difficulty in semantically impaired AD patients? Deteriorated knowledge of the test items represented in semantic memory cannot fully explain our observations, because the semantically impaired AD patients were relatively accurate in their category membership judgments of certain stimuli—foils that do not overlap with the target category. Indiscriminately compromised retrieval of semantic information cannot easily account for semantically impaired AD patients’ performance profile, because they were quite accurate at judging certain test items. The most parsimonious explanation, we believe, is that the similarity judgments contributing to the identification of category information in semantic memory is compromised in some semantically impaired AD patients. This similarity process involves a mental comparison between test items and something like an ideal exemplar of a category (Rips, 1989; Smith & Sloman, 1994). An impairment of this process would result in great difficulty discriminating between category members and foils that overlap semantically with the target category and presumably would limit distinctions between high and low representative category members, but it would be less likely to interfere with judgments of unrelated stimuli that differ from category members in many ways. The connectivity pattern of left posterior superior temporal—inferior parietal cortices with modality-specific association brain regions is ideally suited to support such a comparison process (Mesulam, 1985), and this brain region is frequently compromised in AD (Arnold, Hyman, Flory, Damasio, & van Hoesen, 1991). Functional cerebral defects in this left posterior superior temporal—inferior parietal cortical area have been correlated with impaired category judgments in AD (Grossman, Payer et al., in press), and activity in this brain region appears to be reduced in semantically impaired AD patients compared to AD patients with relatively preserved semantic memory (Grossman, White-Devine, et al., 1997).

We failed to find a selective effect for ontologic difficulty in the subgroup of AD patients with a semantic memory impairment. This is consistent with several other studies of AD that have failed to reveal a difference between natural kinds and manufactured artifacts on a variety of tasks, including recognition naming (Tippett et al., 1996), and category-naming fluency and drawing fluency (Mickanin et al., 1994). Category-specific difficulty for natural kinds may be related in part to some other, nonsemantic aspect of this judgment task. One possibility has focused on the relative importance of appearance attributes for distinguishing among natural kinds compared to artifacts (Farah & McClelland, 1991; Warrington & McCarthy, 1987; Warrington & Shallice, 1984). Based on the work of Flores d’Arcais (Flores d’Arcais & Schreuder, 1987; Flores d’Arcais et al., 1985), we tested this possibility by looking for an interaction effect of category with material. Appearance features are more evident in pictures than in words. Thus, category-specific differences should have been more evident in picture judgments than word judgments. However, this was not found. Relatedly, Chertkow’s (Chertkow et al., 1992) evaluation of category-specific difficulty in semantically impaired patients failed to reveal differences between appearance attributes and function attributes. An alternative account may be related to the anatomic distribution of disease in AD. Inferior aspects of the left temporal lobe thus appear to contribute to category-specific phenomena (Damasio, Grabowski, Tranel, Hichwa, & Damasio, 1996; Martin, Wiggs, Ungerleider, & Haxby, 1996; Perani et al., 1995), and this brain region may be compromised in some AD patients (Arnold et al., 1991). Additional research is needed to assess this hypothesis in subgroups of AD patients.

Several caveats must be kept in mind when evaluating our
results. This study was conducted in a university-based clinic where demented patients were referred for specialized diagnostic evaluation and treatment, and there may have been some undetected bias in the AD patients volunteering to participate in this study. We assessed patients with a dementia that is mild to moderate in severity, and our findings can be generalized only to this subgroup of AD patients. The analysis of performance in subgroups of AD patients with specific cognitive characteristics has resulted in a relatively small number of patients in each subgroup, and additional studies are needed with larger numbers of AD patients that are relatively homogeneous with respect to the cognitive feature under study. The qualitative analyses of category judgments were based on the same data that were used to classify AD patients into subgroups, and future studies should use independent criteria for patient subgrouping and should assess other aspects of semantic memory. The representativeness levels used in this report were based on studies of words, and future investigations should include independent judgments of representativeness from pictures. With these shortcomings in mind, our findings suggest that AD patients with a semantic memory impairment are limited in their sensitivity to the representativeness of stimuli on a category membership judgment task. These findings emphasize the importance of the similarity process for the identification and categorization of specific concepts during normal processing of semantic memory.

References


