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Effects of Relatedness and Number of Distractors on Attribute Judgments in Alzheimer's Disease

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Participants made judgments about the relative salience of category exemplars (e.g., fruit: apple or grape) or parts (e.g., plane: wings or seats). Mildly affected Alzheimer's disease (AD) patients were as accurate but slower than normal controls, and their response times increased more for related (e.g., apple, grape, or fig) than unrelated (e.g., apple, gym, bandit) choices as the number of alternatives was increased from 2 to 3. Performance (accuracy and response times) of moderate–severely affected patients was poorer still, but number of distractors and relatedness did not interact. In combination with previous findings (e.g., M. K. Johnson, A. M. Hermann, & J. L. Bonilla, 1995), these results suggest that the reflective processes necessary for deciding among competing alternatives show disruption early in the disease process. Such processing deficits would compound any difficulties arising from a degrading semantic structure.

Patients with presumed Alzheimer's disease (AD) show impairment on a range of semantic memory tasks (see Gainotti, 1993; Nebes, 1989, for reviews). Whether this reflects an erosion or disorganization of semantic structure or, alternatively, whether it reflects processing deficits overlaid on an intact set of semantic associations is the subject of considerable research and debate (Chan, Butters, Salmon, & McGuire, 1993; Hartman, 1991; Nebes, Martin, & Horn, 1984; Ober & Shenaut, 1995). Although most results can be interpreted as reflecting either degraded structure or disrupted processing (e.g., Johnson & Hermann, 1995; Johnson, Hermann, & Bonilla, 1995), it is clear that task demands markedly affect the performance of AD patients (Bayles, Tomoeda, Kaszniak, & Trosset, 1991; Cox, Bayles, & Trosset, 1996; Nebes, 1992). That is, when the demand for reflectively generated responses (e.g., deliberate evaluation) is high, AD patients appear especially impaired; when fewer such demands are made, AD patients' performance often appears quite similar to that of age- and education-matched control participants.

Consideration of such task demands might help account for an apparent inconsistency in the results assessing semantic structure in AD patients found with verification tasks on the one hand and choice tasks on the other. Johnson et al. (1995) asked AD patients to verify category, part, property, and function attributes (e.g., "Is this a kind of dog? collie"; "Is this a part of a bicycle? wheels"). The importance of the attributes' relation to its concept (its typicality) was varied (e.g., bicycle: wheels, gears, basket; cup: sip, measure, scoop). AD patients, like control participants, made more errors and responded more slowly as typicality decreased across all attribute types. This pattern suggests that, whether the overall AD deficit is from degraded structure or from disrupted processing, the relative salience or accessibility of concepts is maintained in the mild-to-moderate stages of AD (see also Nebes, Boller, & Holland, 1986).

Apparently contradictory results were reported by Grober, Buschke, Kawas, and Fuld (1985, Experiment 3). They asked mixed-etiology dementia patients and matched control participants to judge attribute importance for various test nouns. Each test noun was presented with the instruction to "think about the word's meaning." This was followed by the presentation of three words selected to be of essential, nonessential, and intermediate importance to the test noun (e.g., airplane: fly [essential]; luggage [nonessential]; radar [intermediate]). Participants were instructed to "choose the word that was most important to the concept." After each choice, the chosen item was removed and the participant was instructed to choose from the remaining two, "which word was next in importance to the concept." The dementia group ordered significantly fewer triples correctly than did the control group, although their performance was better than would be expected by chance. Further analysis indicated that the ranking of the essential attributes was different for the

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two groups such that the dementia participants considered the essential attributes to be of less importance to the meaning of the concept three times more often than did the control participants. Grober et al. concluded that dementia may result in a disruption in the relative salience of attributes.

One possible explanation for the difference in conclusions reached by Grober et al. (1985) on the one hand and Johnson et al. (1995) and Nebes et al. (1986) on the other is that the task demands were greater in the Grober et al. study. In Johnson et al., participants were simply asked yes–no questions about whether one concept was related to the other in the stated way (e.g., category, part), and relative salience was inferred from their accuracy and response times. In contrast, in Grober et al., participants were required to directly evaluate the relative salience of various concepts. Such evaluations presumably are more reflectively demanding, requiring participants to, for example, keep information *refreshed* about more than one concept so that activation does not decay before the task is complete, *note* relations between the concepts, and *shift* among various aspects of meaning or attributes of the concepts (e.g., Johnson, 1992; Johnson & Hirst, 1993). Thus, the task of choosing among alternatives, as in the Grober et al. study, is more difficult (i.e., more reflectively demanding) than accepting or rejecting a single alternative. A more revealing outcome would be if AD patients had a relatively harder time choosing between related than between unrelated alternatives. This finding would suggest that AD patients experience some particular confusion between conceptually related items that is beyond the problems they have simply dealing with more information.

In the present study, we varied task demands by varying both the number of items participants had to choose from and the semantic closeness of the distractors. For example, for the question, "Which part do you think of first when you think of a plane?," the target answer ("wings") appeared with either one or two related ("seats," "floor") or unrelated ("toast," "south") alternatives. Others have recently demonstrated that increasing task demands seriously compromises AD patients' performance (Bayles et al., 1991). Our initial hypothesis was that increasing either the number of distractors or the relatedness of the distractors would disproportionately hurt the AD patients' performance relative to the control participants' performance.

Although an explanation in terms of task demands could potentially resolve the inconsistency between the Johnson et al. (1995) and Grober et al. (1985) studies, a finding reported by Cronin-Golomb, Keane, Kokodis, Corkin, and Growdon (1992) suggests that the overall picture may be more complicated. In their study, a mixed-severity group of AD patients and elderly control participants were asked to rank three exemplars in order of their importance to their category. As in Grober et al. (1985), participants were asked to first choose the most typical exemplar, which was then removed, and then the most typical exemplar from the two remaining. The rankings provided by the elderly control participants and AD patients were not different.

One possible reason for the contradictory outcomes of the Cronin-Golomb et al. (1992) and Grober et al. (1985) studies is that Cronin-Golomb et al. tested only category-exemplar relations whereas Grober et al. tested a mixed sampling of semantic relations. There is evidence that category membership relations are more preserved relative to other semantic relations (Johnson & Hermann, 1995; Martin & Fedio, 1983; Warrington, 1975).[1] If so, questions regarding category relations may show less sensitivity to task demands.

We sought to directly investigate the effect of increasing task demands for making semantic judgments. To increase the generality of our findings, we used two kinds of semantic relations (categories and parts). Note that this study was limited to the investigation of task difficulty effects and does not directly address the issue of the relative preservation of category versus part attribute knowledge in AD patients (the materials were not constructed for that purpose but see Johnson et al., 1995, for findings related to this issue). Of interest was any sensitivity to increased task demands that would be apparent, especially early in the disease. The answer to this question is not clear from comparing across reported studies because materials differed and the data from mild and moderate–severely affected AD patients were not provided separately (Cronin-Golomb et al., 1992; Grober et al., 1985).

Method

Participants

Patients were diagnosed as having probable AD as defined by the National Institute of Neurological and Communicative Disorders and Stroke (NINCDS) and the Alzheimer's Disease and Related Disorders Association (ADRDA) work group (McKhann et al., 1984) and had no history or signs of other psychiatric or neurological disease, including multi-infarct dementia. Thirty-three patients were recruited from area physicians and psychologists in New Jersey and Pennsylvania (see Author Note). Thirty-three normal elderly controls matched for age, gender, and education were either spouses of patients or were recruited from retirement communities in the Princeton area. Patients and controls taking psychotropic medications were not tested.

The Mini-Mental State Examination (MMSE; Folstein, Folstein, & McHugh, 1975) was administered to all 33 patients tested and the last 17 of the 33 elderly control participants tested.[2] AD patients were classified as mildly affected if their MMSE score was 19 or

[1] Nebes and Brady (1988) presented data that appears to contradict the idea that category relations are more preserved than other attributes. In their study, AD patients and normal controls judged whether or not several words (category, associate, physical feature, function, unrelated) were related to a line drawing of an object. Patients were not disproportionately worse at making decisions about physical features and functions for objects than they were at making decisions about categories and associates. However, the fact that the same concepts were tested repeatedly (possibly producing facilitation or interference thereby reducing potential differences) and that data for each type of relation were not analyzed separately (the response times for categories and associates were combined) limits the force of their conclusion that categories are not more preserved than other attributes.

[2] MMSE scores were not obtained for the first 16 controls because of an error in the protocol. Evidence that the elderly

Table 1
Demographic and Psychometric Characteristics of Alzheimer's Disease (AD) Patients and Controls

Group	Gender (*n*)		Age (years)		Education (years)		MMSE[a]	
	Female	Male	*M*	*SD*	*M*	*SD*	*M*	*SD*
Controls	19	14	73.2	6.7	13.3	2.7	28.4[b]	1.8
Alzheimer's								
Mild	10	7	73.1	6.5	12.1	3.2	22.8	2.6
Moderate–severe	7	9	74.6	7.9	14.1	2.7	13.9	3.7

[a]MMSE = Mini-Mental State Examination (maximum score = 30). [b]Seventeen of 33 elderly controls tested.

above (30 possible; $n = 17$); patients with a score of 18 or less were classified as moderate–severely affected ($n = 16$). Table 1 shows the gender, mean ages, years of education, and MMSE scores for the participant groups. There were no significant differences in age and years of education among elderly control participants, mildly affected, and moderate–severely affected AD patients. There was a significant difference between the groups in MMSE scores, $F(2, 47) = 100.75$, $MSE = 8.62$. A Tukey-Kramer test showed that moderate–severely affected AD patients ($M = 13.9$) were more impaired than the mildly affected AD patients ($M = 22.8$), and both patient groups had lower MMSE scores than elderly control participants ($M = 28.4$).

Materials and Procedure

The materials consisted of various common concepts and corresponding high (also called the target), medium, and low typicality items as well as unrelated items for category or part attributes: for example, (category) fruit: apple (high), grape (medium), fig (low), gym (unrelated), bandit (unrelated); (part) plane: wings (high), seats (medium), floor (low), south (unrelated), toast (unrelated). Various concepts were obtained from published norms (Battig & Montague, 1969; McEvoy & Nelson, 1982; Shapiro & Palermo, 1970; Tversky & Hemenway, 1984) or generated by the experimenters. Criteria were that the concept would be likely to be familiar to normal adults and that it shared category membership with at least two other items or that it had at least three identifiable parts. The normative rankings were collected from Princeton University students.[3] The mean typicality rankings (on a 1–3 scale, 1 represents *most typical*) were as follows: (category) high = 1.2; medium = 2.1; low = 2.7; (parts) high = 1.1; medium = 2.1; low = 2.8. Because the target and distractor items for the category and part attributes were not explicitly matched for typicality and, perhaps more importantly, the concepts were not the same in the category and part conditions, strong conclusions about the relative preservation of category versus part attributes cannot be drawn from this study (but see Johnson et al., 1995, for data bearing on this issue). The present study speaks to the specific issue of the effects of task difficulty.

The related choice sets consisted of either two items (target and related distractor) of high and medium typicality (e.g., for fruit: apple, grape) or consisted of three items (target and two related distractors) of high, medium, and low typicality (fruit: apple, grape, and fig). Similarly, the unrelated choice sets consisted of either two items (high typicality target and unrelated distractor) or three items (high typicality target and two unrelated distractors). The category attribute block (72 trials) preceded the part attribute block (28 trials) for all participants. For both the category and part attributes, four test lists were made up so that the targets for any particular concept were paired with either (a) one related distractor, (b) two related distractors, (c) one unrelated distractor, or (d) two unrelated distractors. Each participant received one list for each attribute, representing the four possible trial types without repeating concepts within any given list. Within each list, items representing the four possible trial types were intermixed randomly. The target and distractor items were displayed in a row in the center of the computer screen. Locations of targets and distractors (i.e., left, center, or right) were randomly determined.

Before beginning the task, participants were carefully instructed about how to make their choices, that is, the attribute relation was described. For the category attribute questions, participants were instructed to "pick the word that is a more typical example, that is, the word that people are more likely to think of when they think of the category mentioned." For the part attribute questions, participants were instructed to "pick the part that people are more likely to think of when they think of the object mentioned." Instructions were followed by practice trials (four trials for the category attribute block and four trials for the part attribute block) to determine that the participant understood the task. On each trial, the experimenter read the questions aloud, for example, "Which of these is a more typical kind of fruit?" (for the category attribute block) or "Which part do you think of first when you think of a plane?" (for the part attribute block). Immediately following each question, two or three words (target and distractor[s]) appeared on a computer monitor, and participants were asked to respond by reading their choice out loud. All responses and response times were recorded by the experimenter pressing a key on the microcomputer corresponding to the participants' response. The time from the appearance of the word on the screen to the experimenter's keypress was recorded. We did not have participants press keys or speak into a voice key to eliminate extra task requirements (keeping track of the location of the keys, inhibiting irrelevant vocalizations such as coughing or clearing throat) that might cause a greater cognitive burden on AD patients than control participants (Johnson et al., 1995). Although the experimenter's response contributes to absolute response times, we were not particularly interested in absolute response times (AD patients generally respond more slowly than elderly control participants) but rather in potential interactions of number of distractors and relatedness with group.

Results

Both median response time (RT) and accuracy data were collected. Large variability in the AD patients' data necessitated a log transformation of the RT data to satisfy the assumption of homogeneity of variance. This transformation did not alter the pattern of results from that observed in the

controls for whom we did not collect MMSE scores (no-MMSE controls) were not cognitively impaired comes from a comparison of their data to the elderly controls for whom we did collect MMSE scores. The no-MMSE controls responded significantly faster than the MMSE controls but were less accurate (proportion correct: .87 and .91, respectively) suggesting a speed–accuracy trade-off but not consistent with a dementing process. In addition, when the analyses were re-run excluding the no-MMSE controls' data, the pattern of results remained the same as reported.

[3] Details of the norming study are available from the authors.

Table 2
Proportion Correct Responses for Category and Part Attributes

	Unrelated				Related			
	Two choices		Three choices		Two choices		Three choices	
Group	*M*	*SE*	*M*	*SE*	*M*	*SE*	*M*	*SE*
	Category							
Controls	1.00	.003	1.00	.003	.81	.03	.79	.02
Alzheimer's								
Mild	.99	.01	.98	.01	.81	.02	.75	.03
Moderate–severe	.91	.03	.90	.02	.68	.03	.60	.03
	Part							
Controls	1.00	0	.97	.01	.77	.02	.78	.03
Alzheimer's								
Mild	.99	.01	.94	.02	.75	.04	.75	.04
Moderate–severe	.94	.02	.88	.03	.70	.05	.64	.05

untransformed data that are shown in Table 2 (analyses of RTs reported here were conducted using the transformed data). Simple effect analyses were used to explore significant interactions. All results reported are significant at $p < .05$ unless stated otherwise.

Proportion Correct

Table 2 presents accuracy data for both category and part attributes. A 3 (group: elderly control, mild AD, moderate–severe AD) × 2 (attribute: category, part) × 2 (number of distractors: one, two) × 2 (relatedness of distractor: unrelated, related) analysis of variance (ANOVA) was performed on these data, with attribute, number of distractors, and relatedness of distractors as within-subject variables. This analysis revealed a main effect for group, $F = 20.62$, $MSE = .02$; planned pairwise comparisons indicated that the moderate–severely affected AD patient group was less accurate than both the mildly affected AD patient and elderly control groups. The mild AD patient group and the elderly control group did not significantly differ from each other. The main effect of attribute was nonsignificant ($F < 1$), but the main effects for number and relatedness of distractors were significant, $F = 11.13$, $MSE = .01$, and $F = 329.95$, $MSE = .02$, respectively. All groups were less accurate when more distractors were presented and when the presented distractors were related (these two variables did not interact). None of the interactions with group were significant. In sum, mildly affected AD patients showed no deficit in accuracy relative to controls whereas moderate-severely affected patients did show a deficit. As reported next, RTs proved to be a more sensitive measure of patients' difficulties (see Table 3 and Figures 1 and 2).

Log-Transformed Median RTs

A 3 (group: elderly control, mild AD, moderate–severe AD) × 2 (attribute: category, part) × 2 (number of distractors: one, two) × 2 (relatedness of distractor: unrelated, related) ANOVA on log-transformed median RTs for correct responses yielded the following main effects: group, $F = 15.42$, $MSE = .26$, elderly controls responded faster than mild AD patients, and moderate–severe AD patients were slowest; attribute, $F = 15.29$, $MSE = .01$, part items were responded to faster than category items; number of distractors, $F = 228.06$, $MSE = .004$, responses to trials with one distractor were faster than to trials with two distractors; relatedness of distractors, $F = 13.78$, $MSE = .01$, responses to trials with unrelated distractors were faster than to trials with related distractors. These main effects were qualified by the following interactions.

Two three-way interactions were significant (the four-way interaction did not approach significance, $F < 1$). The first, Group × Attribute × Relatedness of Distractor, $F = 7.10$, $MSE = .004$, is shown in Figure 1, top and bottom. From Figure 1, in general, participants were slower when related distractors were present in the display, but the effect was generally weaker for parts than categories, especially for the mildly affected AD patients.

Most important was the interaction of Group × Number of Distractors × Relatedness of Distractors, $F = 3.44$, $MSE = .003$ (see Figure 2, top and bottom). Whereas elderly control participants were slower when distractors were related or when more information was presented (i.e., more distractors), the combination of these two factors did not produce further cost; that is, elderly controls were not especially slower when asked to choose from a set that included a greater number of related distractors compared to when distractors were unrelated (see Figure 2, top and bottom). In contrast, for mildly affected AD patients, the combination of relatedness and more distractors was important. That is, mildly affected AD patients were especially slow when choosing from larger related item sets. Furthermore, in a direct comparison between elderly controls and mild AD patients, the Group × Number of Distractors × Relatedness of Distractors interaction was reliable, $F(1, 63) = 5.80$, $MSE = .003$. The combination of relatedness and more distractors had a greater impact on mild AD

Table 3
Untransformed Median Response Times (in Seconds) for Correct Responses for Category and Part Attributes

	Unrelated				Related			
	Two choices		Three choices		Two choices		Three choices	
Group	*M*	*SE*	*M*	*SE*	*M*	*SE*	*M*	*SE*
	Category							
Controls	1.21	0.05	1.47	0.06	1.41	0.09	1.62	0.10
Alzheimer's								
Mild	1.76	0.13	2.13	0.17	2.13	0.15	2.80	0.22
Moderate–severe	2.66	0.49	3.79	0.88	3.15	0.73	4.39	1.14
	Part							
Controls	1.14	0.05	1.40	0.06	1.25	0.08	1.50	0.09
Alzheimer's								
Mild	1.75	0.15	2.10	0.27	1.60	0.14	2.13	0.21
Moderate–severe	3.05	0.86	3.64	0.91	3.75	1.16	4.18	1.09

patients' RTs than on elderly controls' RTs. A similar comparison between mild and moderate–severe AD patients showed a similar pattern: mildly affected AD patients' were reliably more affected by the combination of relatedness and more distractors than were moderate–severe AD patients, $F(1, 63) = 4.93$, $MSE = .003$. The effect of relatedness did not reach significance in an analysis of the moderate–severely affected AD patients' data, however, the effect of number of distractors did. When two distractors were presented, their RTs were slower than when only one distractor was presented.

Discussion

This investigation sought to assess the ability of AD patients to make judgments about relative saliency for two types of semantic information: exemplars of categories and parts of objects, under varying task demands. The results showed that AD patients had more difficulty than elderly controls when asked to choose the most typical exemplar of a category or the most salient part of an object, especially when task difficulty was increased by including related distractors in the choice set. This difficulty was best reflected in the RT data. Though the AD patients were more accurate than chance (mildly affected AD patients were as accurate as elderly controls), they were slower to respond. Furthermore, mildly affected patients' RTs were affected by our manipulations of number and relatedness of distractors to the target: Mildly affected AD patients found choosing the target in the presence of more related distractors to be more difficult than did elderly controls. This finding illustrates how RT measures may be especially useful for identifying impairments that are not severe enough to preclude accurate performance (cf. Pate, Margolin, Friedrich, & Bentley, 1994). Finally, though the moderate–severely affected AD patients were responding with accuracy well above chance, their RTs indicated that increasing the number of distractors made the task especially difficult for them.

AD patients have shown robust typicality effects in verification tasks (Johnson et al., 1995; Nebes et al., 1986; Nebes & Brady, 1990), thereby suggesting that attribute organization remains orderly. However, Grober et al. (1985) found evidence for disorganization using a choice task. Further complicating the picture, Cronin-Golomb et al.

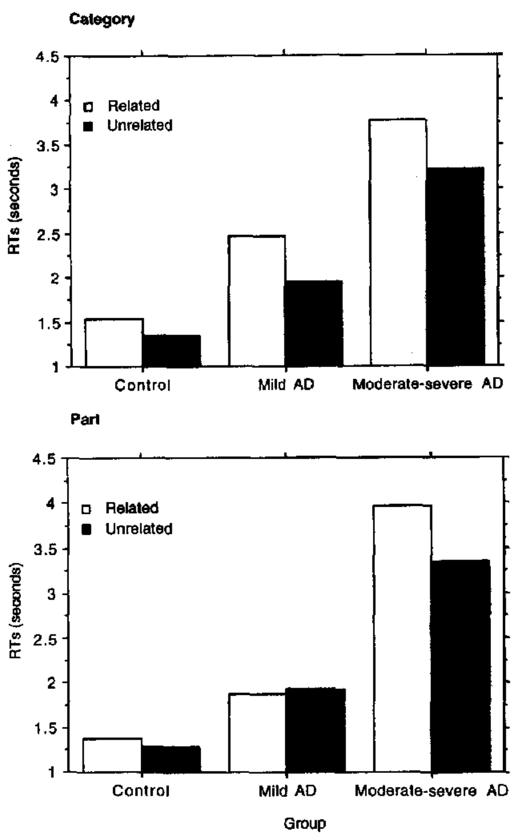

Figure 1. Median response times (RTs) in seconds for correct responses to category items (top) and part items (bottom) by controls and mild and moderate–severely affected Alzheimer's disease (AD) patients. Open bars represent RTs for sets containing related distractors; filled bars represent RTs for sets containing unrelated distractors.

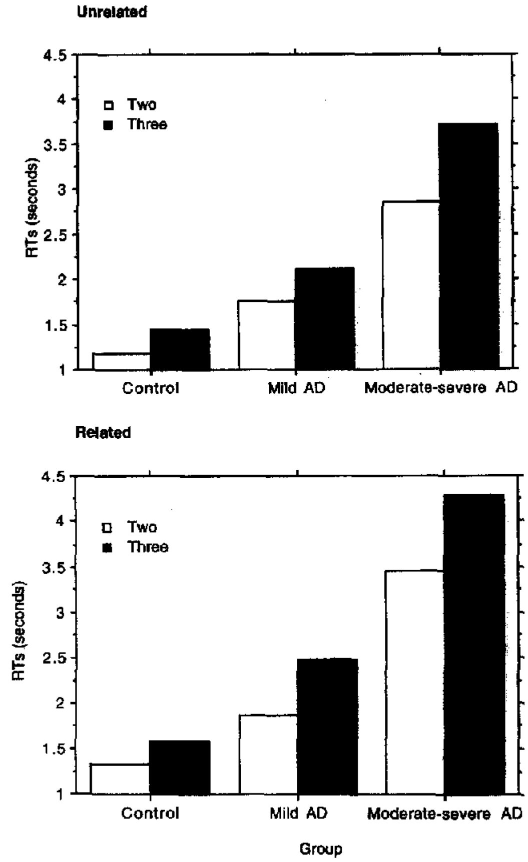

Figure 2. Median response times (RTs) in seconds for correct responses to choice sets containing unrelated distractors (top) and choice sets containing related distractors (bottom) by controls and mild and moderate–severely affected Alzheimer's disease (AD) patients. Open bars represent RTs for choice sets consisting of two items (i.e., one distractor and one target); filled bars represent RTs for choice sets consisting of three items (i.e., two distractors and one target).

(1992), also using a choice task, found evidence for intact organization. Some possible reasons for the discrepancies include: (a) task demands in verification tasks differed from those in choice tasks; (b) there were differences in patient characteristics (Grober et al.'s dementia patients were of mixed etiology; Cronin-Golomb et al.'s AD patients were of mixed severity, and data for mildly and moderately affected AD patients were not provided separately); and (c) type of semantic relations tested varied from strictly category-exemplar (Cronin-Golomb et al.) to an assortment of relations (Grober et al.). The data presented here in combination with previous findings (Johnson et al., 1995) suggest that AD patients are more likely to show deficits in relative saliency of concepts on choice than on verification tasks, and RT measures may be more sensitive to deficits than accuracy measures.

In the present study, adding a second related distractor disproportionately slowed decisions in the mildly affected AD group beyond what occurred from adding an unrelated distractor. The effect of increasing the number of related items on mildly affected AD patients' performance is notable considering that AD patients show relatively normal organization for category and part attributes in a verification task (see Johnson et al., 1995, for these data) and suggests an important role for processing interpretations in understanding AD deficits. Related distractors in the choice set require deliberate evaluation of each alternative whereas, among unrelated distractors, a target item could potentially be chosen simply on the basis of an association with the target concept. As more related distractors are presented, determining the semantic relations among the items and evaluating the weight of each item's connection to the given category or object becomes more reflectively demanding (Johnson & Hirst, 1993). Consistent with descriptions of AD deficits as arising from difficulty with effortful processing (Nebes et al., 1984) or strategic retrieval (Hartman, 1991), these findings suggest that such attentional or working memory processes are seriously compromised in AD (Baddeley, Bressi, Della Sala, Logie, & Spinnler, 1991).

These results suggest that in early stages of AD, patients have particular difficulty evaluating and deciding among related alternatives. In later stages, performance is poorer still, perhaps because patients are having more overall difficulty processing any type of information. This difficulty processing information could arise from structure degradation. That is, it is possible, and perhaps likely given the pattern and extent of neuropathology characteristic of the disease (Arnold, Hyman, Flory, Damasio, & Van Hoesen, 1991; Arnold, Hyman, & Van Hoesen, 1994), that AD results in both "graceful" breakdown of semantic memory structure (i.e., relations remain orderly but concept-specifying features may be degrading; Martin, 1992) and information-processing deficits (Nebes, 1992).

Processing deficits seen in AD could be described within the context of a general cognitive architecture called a multiple-entry, modular memory system (MEM; Johnson, 1983, 1992; Johnson & Hirst, 1993). The MEM framework provides a way of specifying global changes in effortful, strategic, attentional, or working memory functioning in terms of component cognitive processes. In this framework, memory processes are organized into two major systems, perceptual and reflective. The perceptual system includes component processes that support and record perceptual processing. The reflective system includes component processes that are necessary for the manipulation and retrieval of information for such purposes as planning, evaluating, and comparing. Normally, these processes function under the strategic guidance of ongoing agendas that consist of plans for recruiting component processes in the service of goals. Agendas serve to activate and to guide the component processes necessary for the completion of some task, whether it be to evaluate the relative importance of a concept's attributes or to guide the retrieval of animal terms (e.g., Johnson, 1992; Johnson & Hirst, 1993).

Within this framework, perceptual processes that result in semantic activation from perceptually processing (e.g., reading) words appears to remain largely intact in AD, as illustrated by normal "automatic" semantic priming in AD (see Ober & Shenaut, 1995). The cognitive deficits resulting from AD could be interpreted as a consequence of a disruption in the connection between the goal-setting agendas and the reflective subprocesses necessary to meet them or as a disruption in one or more reflective subprocesses. This disruption manifests itself in the present task as difficulty making use of activated semantic information for purposes of comparing and evaluating various alternatives. In particular, as the number of related items is increased, heavier demands are made on the reflective system. For example, reflective subprocesses are required for *refreshing* information so that activation does not decay before the task is complete, *noting* relations between the items, and *shifting* to other aspects of meaning or attributes of the items (Johnson, 1990, 1992; Johnson & Hirst, 1993).[4]

Structure degradation in AD has been characterized as a loss of specifying features or attributes in a semantic network resulting in a preservation of categorical knowledge yet an increasing difficulty in distinguishing concepts within the same semantic category (Martin, 1992; Martin & Fedio, 1983). Results from a positron emission tomography (PET) study indicate that knowledge of objects is represented as a distributed network, such that specifying features or attributes of concepts appear to be stored near the cortical regions that mediated their perception (Martin, Haxby, Lalonde, Wiggs, & Ungerleider, 1995; see also Johnson, Kounios, & Nolde, 1996). Recently, Milberg, Blumstein, Katz, Gershberg, and Brown (1995) described how the random destruction of nodes or their connections in the semantic network (as might occur in AD) could result in processing inefficiencies though the general organization of the network might be preserved. This description is consistent with findings of relatively normal typicality effects in AD patients (Johnson et al., 1995; Nebes et al., 1986).

In summary, the present results indicate that mildly

[4] These might all be thought of as "working memory" processes. We prefer, however, to use the MEM model to emphasize that the specific component processes that are disrupted in AD remain to be specified.

affected AD patients have difficulty making evaluative judgments especially when the alternatives are related. Given that the organization of attribute information, in terms of relative importance, appears largely intact when assessed indirectly (i.e., without the requirement for deliberate evaluation; Johnson et al., 1995), these results gathered from a more demanding task suggest that a processing deficit is characteristic of the disease. That is, one or more of those cognitive processes (e.g., *refreshing*, *noting*, *shifting*; see Johnson, 1983, 1992; Johnson & Hirst, 1993) that enable effective decision making in the presence of related information may begin to deteriorate in the earliest stages of AD. Nevertheless, our results are also consistent with the proposal that feature-specifying information is lost in AD, thereby making concepts, especially related concepts, more confusable (Hodges, Salmon, & Butters, 1992; Martin, 1992; Milberg et al., 1995). Of course, disrupted processing would compound any deficits arising from degraded structure. Thus, the relative rates of loss of various reflective functions as AD progresses remains to be sorted out, as does the relation between processing difficulties and loss of features from the representation of semantic knowledge. Future work focusing on the earliest stages of AD might be particularly useful in this regard, because such patients are still able to perform at relatively high levels in cognitive tasks; thus, it is possible to assess the effects of a wider range of variables (e.g., relatedness). Studying these more mildly affected patients, focusing on various specific component reflective and perceptual processes (e.g., Johnson & Hirst, 1993), and using dependent measures more sensitive than simple accuracy (e.g., response time) would clarify the probable interactions between disrupted processing and degraded structure.

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