Neuropsychology
1997, Vol. 11, No. 3, 400–412


0894-4105/97/$3.00

# Impairment in Category Fluency in Ischemic Vascular Dementia

Tania Giovannetti Carew and Melissa Lamar
Drexel University and Crozer-Chester Medical Center

Blaine S. Cloud
Graduate Hospital

Murray Grossman
Hospital of the University of Pennsylvania

David J. Libon
Drexel University and Crozer-Chester Medical Center

The underlying mechanisms for impaired output on letter (*F, A,* and *S*) and category (e.g., animal) word list generation (WLG) tasks in subcortical ischemic vascular dementia (IVD) were investigated. Normal control (NC) and Alzheimer's disease (AD) participants were also studied. IVD and NC participants performed better on category than letter WLG tasks, whereas the opposite was observed among AD participants. IVD participants produced fewer responses than AD participants on letter WLG tasks, but there was no difference between AD and IVD participants on the "animal" WLG task. AD participants scored lower than IVD and NC participants on animal WLG indexes measuring semantic knowledge. There were few differences between IVD and NC participants. The reduced output on the animal WLG task for IVD participants is consistent with search–retrieval deficits. The reduced output of AD participants may be caused by degraded semantic knowledge.

Tests of letter and category word list generation (WLG) have been extensively used to study various aspects of cognitive functioning in both normal aging and a wide range of dementing illnesses. In an attempt to investigate the underlying mechanisms for successful performance on category WLG tasks, Gruenewald and Lockhead (1980) administered the animal WLG task to normal control (NC) participants. Two findings emerged from this study. First, the authors observed that clusters of semantically related responses (i.e., responses that shared many attributes) were produced relatively quickly. Second, Gruenewald and Lockhead (1980) observed that participants "shifted" or switched into other semantic clusters only after a comparatively long response latency. They proposed a two-component model to describe the performance of normal participants on category WLG tasks and concluded that the ability to generate successive clusters of semantically meaningful responses is independent from the ability to search and shift from one cluster to another.

Category WLG tasks have been used to investigate the semantic knowledge deficits associated with Alzheimer's disease (AD). For example, it has been shown that output on semantically related WLG tasks declines as the illness advances (Ober, Dronkers, Koss, Delis, & Friedland, 1986; Rosen, 1980). In addition, AD participants tend to produce fewer responses on semantically based WLG tasks than phonemically based WLG tasks when compared to NC participants (Butters, Granholm, Salmon, Grant, & Wolfe, 1987; Weingartner, Kawas, Rawlings, & Shapiro, 1993).

AD participants have also been shown to make more category violations on semantic WLG tasks and to produce fewer responses per cluster (i.e., farm animals, fruits, and vegetables) than NC participants (Binetti et al., 1995; Martin & Fedio, 1983; Mickanin, Grossman, Onishi, Auriacombe, & Clark, 1994; Ober et al., 1986). Whether these findings are due to an actual loss or degradation of semantic information (Chan et al., 1993; Chertkow & Bub, 1990; Hodges, Salmon, & Butters, 1992; Martin, 1992) or to an inability to access semantic information that may be largely intact (Bonilla & Johnson, 1995; Nebes, 1989; Nebes, Martin, & Horn, 1984; Nebes, Brady, & Huff, 1989) has been hotly debated.

A different pattern of performance on letter and category WLG tasks has been reported among participants suffering from dementing illnesses known to disproportionately impair executive control functions, such as Huntington's disease (HD), Parkinson's disease (PD), and progressive supranuclear palsy (PSP). For example, over time, HD and PSP participants exhibit greater decline on phonemically based rather than semantically based WLG tasks, a pattern of performance opposite from that found in AD. Similarly, demented participants with PD have been shown to produce more responses on semantic as opposed to phonemic WLG tasks (Bayles, Trosset, Tomoeda, Montgomery, & Wilson, 1993; Beatty, Staton, Weir, Monson, & Whitaker, 1989). Comparisons between AD, HD, and PSP participants have shown that HD and PSP participants produce fewer responses on phonemic WLG tasks. On semantic WLG tasks, however, HD, PSP, and AD participants are equally impaired (Butters et al., 1987; Hodges, Salmon, & Butters, 1990; Rosser & Hodges, 1994; Monsch et al., 1994).

Tania Giovannetti Carew, Melissa Lamar, and David J. Libon, Neuropsychology Program, Drexel University, and the Neuropsychology Service, Department of Psychiatry, Crozer-Chester Medical Center, Upland, Pennsylvania; Blaine S. Cloud, Department of Neurology, the Graduate Hospital, Philadelphia, Pennsylvania; Murray Grossman, Department of Neurology, Hospital of the University of Pennsylvania, Philadelphia, Pennsylvania.

This work was supported, in part, by the U.S. Public Health Service (AG09399). We thank Gail Silverstein, Laurel Buxbaum, Myrna Schwartz, and Laura P. Sands for their helpful comments.

Correspondence concerning this article should be addressed to David J. Libon, Neuropsychology Service, Department of Psychiatry, Crozer-Chester Medical Center, Upland, Pennsylvania 19013.

An analysis of the organization of responses on category WLG tasks has shown that HD participants produce fewer clusters (i.e., successive responses from the same category) than AD and NC participants (Troster, Salmon, McCullough, & Butters, 1989). Using multidimensional scaling techniques, Chan and colleagues (Chan et al., 1993) showed that the semantic networks of HD participants are similar to NC participants. By contrast, the semantic networks of AD participants are severely disrupted. In general, these studies and others suggest that the reduced output on semantic WLG tasks in dementing illness such as HD, PD, and PSP may be explained by impaired initiation and deficient retrieval of semantic information, rather than actual degradation of semantic knowledge stores (Butters et al., 1987; Hodges, Salmon, & Butters, 1990; Milberg & Albert, 1989; Monsch et al., 1994; Randolph, Braun, Goldberg, & Chase, 1993; Rosser & Hodges, 1994). A similar conclusion was reached in studies of patients with focal frontal lobe lesions (Martin, 1992; Randolph et al., 1993).

Only a few studies have compared participants with AD and cerebrovascular dementia on WLG tasks, and no between-group differences have been reported (Bar, Benedict, Tune, & Brand, 1992; Bernard et al., 1992; Fischer, Gatterer, Marterer, & Danielczyk, 1988; Villardita, 1993). However, a variety of methodological problems may have been present in these studies. The rather advanced level of dementia (mean Mini-Mental State Examination = 16.3; Bar et al., 1992; Fischer et al., 1988) and the use of categories that are somewhat obscure (e.g., "furniture" in Fischer et al., 1988; "parts of buildings" in Bernard et al., 1992) may have minimized between-group differences. Also, letter and category WLG tasks were not directly compared, and an analysis of response style (e.g., clustering, etc.) on category WLG tasks was not carried out in any of these studies.

An association between significant periventricular and deep white matter alterations and greater impairment in the area of executive control, but relatively preserved performance on recognition memory tests, has been reported by researchers studying both healthy, elderly participants (Austrom et al., 1990; Boone et al., 1992; Breteler et al., 1994; Matsubayashi, Shimada, Kawamoto, & Ozawa, 1992; Schmidt et al., 1993; Ylikoski et al., 1993) and demented participants (Bogdanoff, Bonavita, Libon, Cass, & Cloud 1994; Fukuda, Kobayashi, Okada, & Tsunematsu, 1990; Gupta et al., 1988; Ishii, Nishihara, & Imamura, 1986; Kertesz, Polk, & Carr, 1990; Podell, Lamar, Resh, Libon, & Kennedy, 1996). Bogdanoff et al. (1994) and Podell et al. (1996) compared participants with AD and ischemic vascular dementia (IVD) caused by periventricular and deep white matter alterations. Bogdanoff et al. (1994) found that IVD participants made more perseverations and obtained lower scores on tests of executive control as compared to AD participants. On the California Verbal Learning Test (CVLT; Libon et al., 1996), IVD participants exhibited less forgetting, obtained higher test scores on all delayed free and cued recall and recognition test conditions, and made fewer intrusion errors than AD participants. Podell et al. (1996) also found that IVD participants made more perseverations than AD participants and that the underlying mechanisms for the production of perseverations were different for each group of demented participants. For example, the perseverative behavior of IVD participants was associated with specific problems in terminating and shifting into new mental sets, whereas the perseverative behavior of AD participants appeared to be related to an inability to distinguish between semantic representational concepts.

The goal of this research is to investigate the mechanisms for the breakdown in performance on category WLG tasks in participants with IVD associated with subcortical periventricular and deep white matter alterations. AD and NC participants were used as control groups. Both semantic and phonemic WLG tasks were administered. As noted earlier, when the output on phonemic and semantic WLG tasks has been directly compared, participants whose dementia is associated with subcortical neuropathology have sometimes been shown to produce fewer responses on letter as compared to category WLG tasks (Bayles et al., 1993; Beatty, Monson, et al., 1989; Beatty, Staton, et al., 1989), with AD participants producing the opposite profile (Hodges, Salmon, & Butters, 1990). Because the neuropathology of our IVD participants is primarily confined to subcortical regions of the brain, our first prediction is that IVD participants will produce fewer responses on the letter rather than on the animal WLG task, whereas AD participants will produce the opposite profile.

Based on Gruenewald and Lockhead's (1980) model, we examined successive responses on the category (animal) WLG task and developed separate indices to assess the degree to which consecutive responses are semantically associated and organized into clusters. Past studies have shown that HD participants produce fewer clusters on semantically related fluency tasks (Troster et al., 1989). According to Gruenewald and Lockhead's model, we suggest that the cluster index we describe later is highly dependent upon executive control processes necessary to shift mental set to efficiently search for semantic information. Therefore, because IVD participants demonstrate a disproportionate degree of impairment in executive control functions as compared to other domains of cognitive functioning, our second prediction is that IVD participants will produce fewer clusters than AD participants.

Our third prediction is that IVD participants will demonstrate little to no impairment in semantic knowledge on the animal WLG task as compared to NC participants. Therefore, it is our expectation that IVD participants will obtain comparable scores to NC participants on animal WLG indices designed to measure the strength of association of semantic information. By contrast, AD participants will obtain lower scores on these indices than IVD and NC participants.

To bolster our claim that the underlying mechanisms for the reduced output on category WLG tasks in AD and IVD are different, the relationship between the animal WLG indices to be described later and performance on other neuropsychological tests such as the Boston Naming Test (BNT; Kaplan, Goodglass, & Weintraub, 1983), a test that is related to semantic knowledge functioning, and the Wechsler Memory Scale—Mental Control subtest (WMS–MC; Wechsler, 1945) and the Goldberg Graphical Sequence Test (GST; Goldberg & Tucker, 1979), tests that are related to executive control, were analyzed. Our fourth prediction is that among AD participants performance on the BNT will only be correlated with category WLG indices that measure the integrity of semantic information. Among IVD participants, performance on the WMS–MC and GST tests will only be correlated with category WLG indices that measure the ability to actively search for and retrieve semantic information.

## Method

### Participants

All participants with dementia came from the Crozer-Chester Medical Center's Alexander Silberman Geriatric Assessment Program. This is a 4-day outpatient dementia evaluation program. All patients were examined by a social worker, geriatrician, neurologist, psychiatrist, and neuropsychologist. Appropriate laboratory studies were obtained on all participants. An MRI study of the brain was obtained on all participants except 3 participants in each group who were studied with CT scans. A clinical diagnosis was determined at an interdisciplinary team conference. On the basis of the team diagnosis, 40 participants were given a diagnosis of probable AD consistent with National Institute of Neurological and Communicative Diseases–Alzheimer's Disease and Related Disorders Association criteria (McKhann et al., 1984), and 35 participants were given a diagnosis of probable IVD using the California Criteria of Chui (Chui et al., 1992). In addition to periventricular and deep white matter alterations, all IVD participants had evidence of subcortical stroke on the basis of their MRI or CT scans of the brain and their neurological examinations. Neuroradiological studies indicated that all the cerebrovascular accidents of the IVD participants were primarily located in the centrum semiovale, various nuclei within the basal ganglia, thalamus, and pons. None of the AD participants demonstrated these changes on MRI or CT. Seven IVD participants were excluded because their radiological studies revealed cortical infarcts. Therefore, the IVD group was comprised of 28 participants. There were no differences between the IVD and AD groups on the Mini-Mental State Examination (MMSE; Folstein, Folstein, & McHugh, 1975).

Thirty-one NC participants were also studied. NC participants were included if they obtained a score of 27 or greater on the MMSE and scored 10 or less on the Geriatric Depression Scale (GDS; Yesavage, 1986). Any control or experimental participant who presented with a head injury, seizure disorder, PD, major psychiatric problems including substance abuse, or who was taking psychoactive medication was excluded. These data were gathered on the basis of a clinical interview with the participant and a spouse or other knowledgeable family member. There were no differences between the three groups in age (see Table 1). The NC group, however, had more years of education than the IVD group, $t(57) = 2.07, p < .043$. The NC group also obtained a slightly lower score on the GDS than both the AD, $t(67) = 3.37, p < .001$, and IVD, $t(55) = 3.34, p < .002$, groups.

### WLG Tests

All participants took letter and category fluency tests. On the letter WLG test, participants were given 60 s to generate words, excluding proper nouns, beginning with a specified letter (*F, A, S*).

Table 1
*Means and Standard Deviations for Alzheimer's Disease (AD), Ischemic Vascular Dementia (IVD), and Normal Control (NC) Groups*

| | AD | | IVD | | NC | |
|---|---|---|---|---|---|---|
| Variable | *M* | *SD* | *M* | *SD* | *M* | *SD* |
| Age | 76.8 | 5.9 | 77.7 | 6.0 | 76.4 | 6.6 |
| Education | 12.2 | 2.3 | 11.2 | 3.1 | 12.8 | 2.6 |
| MMSE | 22.2 | 3.0 | 20.8 | 4.4 | 28.8 | 1.1 |
| GDS | 5.6 | 4.3 | 5.5 | 4.0 | 2.5 | 2.6 |

*Note.* MMSE = Mini-Mental State Examination; GDS = Geriatric Depression Scale.

The dependent variable was the number of responses summed across the three letters. In addition, total number of perseverations, intrusion errors (i.e., responses that do not begin with the specified letter or neologisms), and rule violations (i.e., proper nouns) were calculated.

The animal WLG task was administered by asking participants to produce as many names of animals as possible in 60 s. The dependent variable was the total number of responses, excluding perseverations and extracategory intrusion responses ("chair"). The animal WLG task was chosen for the present research because, as will be described later, a wide variety of taxonomic and zoological subcategories already exist for this information. This permits a more fine-grained analysis of participants' performance on this task because of the opportunity to analyze separately both superordinate and subordinate attributes. Participants' responses from the animal WLG task were then coded on one attribute from each of the following six categories.

*1. Size (big, small).* Big animals were defined as being taller than the average human at the shoulder, weighing more than 300 pounds, or both (e.g., giraffe). This operational definition was applied on an a priori basis, because it is concrete and minimizes confusion (see Appendix).

*2. Geographic location (foreign, local).* Foreign animals were defined as animals that are not indigenous to North America (e.g., elephant, jaguar).

*3. Habitat (farm, pet, water, prairie, forest, African-jungle, Australian, widespread).* Farm animals included any animal that is commonly found on a farm or ranch and is kept as livestock (e.g., cow, horse, camel). Pets included common household animals such as cat, dog, gerbil, and parrot. Water animals were defined as animals who either live in the water or are ecologically associated with the water (e.g., beaver). Prairie animals were defined as nondomesticated, grazing animals (e.g., antelope). Forest animals included animals who live in forested temperate climate areas. African-jungle animals were defined as those that live either in Africa or in tropical climates. Australian animals refer to animals only found on the continent of Australia. Animals were classified as widespread if they live in multiple geographic–ecological systems (e.g., rats, bees; Sims, 1980).

*4. Zoological class.* These attributes refer to whether an animal belongs to one of the following taxonomic classes: insects, mammals, birds, fish, amphibians, or reptiles (Sims, 1980).

*5. Zoological orders, families, and related groupings.* These attributes refer to whether an animal belongs to one of the following 18 zoological orders or families (Sims, 1980): feline, canine, equine, ursine, suidae (pigs), bovine, primate, cervidae, marsupial, rodenta and related animals (including mustilidae, skunk; insectora, hedgehog; procyconidae, racoon; leporidae, rabbits, myrmecophagidae, anteater, armadillo, aardvark, sloth), artiodactyla (giraffe, camels), squamata (snakes, lizards), cetacea (whales, dolphins), crocodilia, arachniae (spiders), crustacea (lobsters), and mollusca (octopus, clams).

Ten nontaxonomic but related animal groupings were included in this category of attributes. These included pachyderm, fowl, sea mammals (all ocean mammals excluding whales and dolphins), turtles and tortoises, flightless birds, flying birds, crawling insects, flying insects, freshwater fish, and saltwater fish. Pachyderms were defined as any large, hoofed, thick-skinned mammals and included only the following animals: elephants, rhinoceros, hippopotamus, and tapirs. Fowl were defined as birds commonly used as food or hunted as game. Although these groupings are not formal taxonomic designations, we decided to include these groupings because participants often used these structures in generating responses on the category WLG task.

*6. Diet (herbivore, carnivore, omnivore).* Herbivores included all grazing animals that eat primarily plants or fruit. All meat-eating or flesh-eating animals were coded as carnivores. Animals who eat both vegetables and fruit and meat were coded as omnivores. A scoring key was compiled from the entire corpus of responses produced by all participants (see Appendix). Decisions regarding how to classify animals were based on the work of Sims (1980).

Certainly, this scoring technique is very similar to the animal WLG measures described by Chan et al. (1993); however, there are several differences. Chan and colleagues only scored a subset of the responses produced by their participants and only analyzed them on a limited number of categories or attributes. Our rationale for scoring *all* responses on the *six* categories described previously is twofold. First, because we did not have any way to truly predict what schemata participants might use to organize this information, we did not want to bias our results by imposing any preconceived ideas in the construction of our scoring system. We acknowledge that any number of categories are valid and might have been used. Also, it was not our expectation that participants have explicit knowledge of such taxonomic structures as "artiodactyla" or "squamata." Nonetheless, because taxonomic categories are based on observable characteristics, such as how animals look and make a living, we believe that participants have some implicit knowledge of these groupings. We also felt justified in including a broad array of categories that describe a wide variety of animal characteristics, because it provides an independently derived heuristic mechanism by which animals can be matched on superordinate and subordinate attributes. For example, response strings such as "moose, gorilla, lion, deer" and "cheetah, leopard, lion, tiger" are each characterized as large, wild mammals. However, the latter string is clearly more semantically related than the former. Our scoring system was designed to capture such distinctions. Finally, from a psychometric standpoint, giving participants an opportunity to match consecutive responses on six categories is a way to maximize variance so that the dependent variables derived from these data do not suffer from restriction of range.

After each response was coded on one attribute from each of the six categories described previously, six additional dependent variables were derived.

*1. Association Index (AI).* The AI is the cumulative number of shared attributes between all successive responses divided by the total number of words generated minus one (see Table 2). Table 2 illustrates how the AI was derived. NC participant No. 3024 produced 14 responses. Starting with the second response and moving across the page, "horse" matches with the first response (i.e., "bear") on three attributes (big, local, and mammal). Therefore, the total shared attributes for the first two responses is 3. The third response is "cow." As seen on Table 2, "cow" matched with "horse" on five attributes (big, local, herbivore, mammal, and farm). Thus, a 5 is entered in the column marked "sum of attributes" on the far right in Table 2. Following this procedure of matching each successive response on the 49 attributes listed previously, the total sum of the shared attributes for this participant is 46. The AI for this participant is 3.54 or 46/ (14 − 1). The sum of the shared attributes was divided by the number of responses minus one to guard against inflating the AI, because the attributes of the first response are never actually figured into the sum of the scaled attributes. This index was devised to provide a measure of the organization or strength of association between all consecutive responses.

Upon inspection, it appeared that two sets of attributes were represented. One set of attributes appeared to describe rather general, *superordinate* characteristics of animals. These include the following nine attributes: big, small, foreign, local, herbivore, carnivore, omnivore, mammal, and widespread. By contrast, a second set of attributes appeared to describe relatively specific, *subordinate* characteristics of animals. These attributes included all of the zoological designations of class, order, and family, except for mammal, and all attributes pertaining to habitat except widespread.

For each participant, three separate AIs were compiled based on the number of superordinate attributes (SUPER-AI), the subordinate attributes (SUB-AI), and the TOTAL-AI. The decision to calculate separate AIs was made because the nine superordinate attributes listed previously describe characteristics that are common and generic to many different types of animals. Thus, animals that share these attributes may have only relatively weak or superficial semantic relationships between each other. On the other hand, the subordinate attributes listed previously are restricted to particular subsets of responses and pertain to very specific, defining characteristics of animals. Thus, the ability to generate response strings that are rich in these very specific, defining characteristics may provide a truer or more sensitive measure of the strength or depth of semantic association between successive responses.

Perseverative responses were scored differently from regular responses. In the case of perseverative responses, only those attributes that were in common with the responses that occurred immediately before and after the perseverative response were coded. For example, AD participant No. 1005, shown in Table 2, produced the perseverative response "rhinoceros." Any attribute that was shared by the previous response "goats," the perservative response "rhinoceros," and the following response "dog" was coded. For AD participant No. 1005, the perseverative response effectively linked only one attribute (i.e., mammal) between the previous response "goats" and the following response "dog." No other attributes are shared by all three of these responses. Therefore, a total of 1 (the sum of shared attributes) was used in the calculation of the AI. This alteration in scoring was instituted so as not to bias or inflate the AI measures. Nonspecific responses such as "fish" and "birds" were excluded from the compilation of the AI as well as all of the other indices described later because it is unclear which fish or birds participants had in mind. Therefore, it was not possible to code such responses on all six categories of attributes listed previously.

*2. Number of clusters (CLUSTERS).* CLUSTERS are a group of two or more consecutive responses that share *any* four attributes. The decision to define clusters on the basis of four attributes was made to ensure a minimum degree of association between successive responses. Upon inspection, we felt that clusters defined on the basis of fewer than four shared attributes sometimes resulted in groupings that were not meaningful. For example, although there may be a certain degree of association in a response string such as moose and cow (i.e., big, herbivore, and mammal), there is less intrinsic association in a response string such as frog and ant (i.e., small, native, and widespread). Yet, in both examples, these response strings share three attributes.

As illustrated in Table 2, there were four occasions where NC

Table 2
*Response Coding on the Animal Word List Generation Task*

| Response | Size | | Location | | Diet | | | Zoological class | | | | | | Habitat | | | | | | | | Biological order–family | | | | | | | | | | | | | | | | | | | | | | | | | | | | | Error codes | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Big | Small | Foreign | Local | Herbivore | Carnivore | Omnivore | Mammal | Bird | Fish | Insect | Reptile | Amphibian | Pet | Farm | African/jungle | Prairie | Water | Forest | Australia | Widespread | Arachniae | Artiodactyla | Bovine | Canine | Cervidae | Cetacea | Crawling insects | Crocodilia | Crustacea | Equine | Feline | Flying bird | Flying insect | Fowl | Fresh fish | Land bird | Marsupial | Mollusk | Myrmecophagidae | Pachyderm | Porcine | Primate | Rodentia and related | Salt fish | Sea mammals | Squamata | Turtles | Ursine | Nonspecific response | Perseveration | Phonemic cluster | Sum of attributes | Clusters |
| NC participant No. 3024[a] | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Response 1: bear | x | | | x | | | x | x | | | | | | | | | | | x | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | x | | | | | |
| Response 2: horse | x | | | x | x | | | x | | | | | | | x | | | | | | | | | | | | | | | | x | | | | | | | | | | | | | | | | | | | | | | 3 | |
| Response 3: cow | x | | | x | x | | | x | | | | | | | x | | | | | | | | | x | | | | | | | | | | | | | | | | | | | | | | | | | | | | | 5 | 1 |
| Response 4: duck | | x | | x | | | x | | x | | | | | | x | | | | | | | | | | | | | | | | | | | | x | | | | | | | | | | | | | | | | | | 2 | |
| Response 5: geese | | x | | x | x | | | | x | | | | | | x | | | | | | | | | | | | | | | | | | | | x | | | | | | | | | | | | | | | | | | 5 | 2 |
| Response 6: deer | x | | | x | x | | | x | | | | | | | | | | | x | | | | | | | x | | | | | | | | | | | | | | | | | | | | | | | | | | X | 2 | |
| Response 7: moose | x | | | x | x | | | x | | | | | | | | | | | x | | | | | | | x | | | | | | | | | | | | | | | | | | | | | | | | | | | 6 | 3 |
| Response 8: chicken | | x | | x | x | | | | x | | | | | | x | | | | | | | | | | | | | | | | | | | | x | | | | | | | | | | | | | | | | | | 2 | |
| Response 9: koala | | x | x | | x | | | x | | | | | | | | | | | | x | | | | | | | | | | | | | | | | | | x | | | | | | | | | | | | | | | 2 | |
| Response 10: panda | | x | x | | x | | | x | | | | | | | | x | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | x | | | | 4 | |
| Response 11: zebra | x | | x | | x | | | x | | | | | | | | x | | | | | | | | | | | | | | | x | | | | | | | | | | | | | | | | | | | | | | 4 | |
| Response 12: giraffe | x | | x | | x | | | x | | | | | | | | x | | | | | | | x | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | 5 | |
| Response 13: elephant | x | | x | | x | | | x | | | | | | | | x | | | | | | | | | | | | | | | | | | | | | | | | | x | | | | | | | | | | | | 5 | 4 |
| Response 14: seals | | x | | x | | x | | x | | | | | | | | | | x | | | | | | | | | | | | | | | | | | | | | | | | | | | | x | | | | | | | 1 | |
| AD participant No. 1005[b] | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Response 1: bees | | x | | x | x | | | | | | x | | | | | | | | | | x | | | | | | | | | | | | | x | | | | | | | | | | | | | | | | | | | | |
| Response 2: rhinoceros | x | | x | | x | | | x | | | | | | | | x | | | | | | | | | | | | | | | | | | | | | | | | | x | | | | | | | | | | | | 1 | |
| Response 3: goats | | x | | x | x | | | x | | | | | | | x | | | | | | | | | x | | | | | | | | | | | | | | | | | | | | | | | | | | | | | 2 | |
| Response 4: rhinoceros | P | | P | | P | | | P | | | | | | | | P | | | | | | | | | | | | | | | | | | | | | | | | | P | | | | | | | | | | X | | | |
| Response 5: dog | | x | | x | | x | | x | | | | | | x | | | | | | | | | | | x | | | | | | | | | | | | | | | | | | | | | | | | | | | | 1 | |
| Response 6: beetle | | x | | x | | | x | | | | x | | | | | | | | | | x | | | | | | | x | | | | | | | | | | | | | | | | | | | | | | | | | 2 | |
| IVD participant No. 2004[c] | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Response 1: horse | x | | | x | x | | | x | | | | | | | x | | | | | | | | | | | | | | | | x | | | | | | | | | | | | | | | | | | | | | | | |
| Response 2: mule | x | | | x | x | | | x | | | | | | | x | | | | | | | | | | | | | | | | x | | | | | | | | | | | | | | | | | | | | | | 6 | 1 |
| Response 3: lion | x | | x | | | x | | x | | | | | | | | x | | | | | | | | | | | | | | | | x | | | | | | | | | | | | | | | | | | | | | 2 | |
| Response 4: cougar | x | | | x | | x | | x | | | | | | | | | | | | | x | | | | | | | | | | | x | | | | | | | | | | | | | | | | | | | | | 4 | 2 |
| Response 5: wolf | | x | | x | | x | | x | | | | | | | | | | | x | | | | | | x | | | | | | | | | | | | | | | | | | | | | | | | | | | | 3 | |
| Response 6: jackal | | x | | x | | x | | x | | | | | | | | | | | x | | | | | | x | | | | | | | | | | | | | | | | | | | | | | | | | | | | 6 | 3 |
| Response 7: camel | x | | x | | x | | | x | | | | | | | x | | | | | | | | x | | | | | | | | | | | | | | | | | | | | | | | | | | | | | 1 | 1 | |
| Response 8: horse | P | | | P | P | | | P | | | | | | | P | | | | | | | | | | | | | | | | P | | | | | | | | | | | | | | | | | | | | X | | | |

*Note.* NC = normal control; AD = Alzheimer's disease; IVD = ischemic vascular dementia; P = perseverative response; AI = Association Index.
[a]AI = 3.54; CLUSTERS = 4; SIZE = 2.75; PERCENT = 79. [b]AI = 1.50; CLUSTERS = 0; SIZE = 0; PERCENT = 0. [c]AI = 3.67; CLUSTERS = 3; SIZE = 2.0; PERCENT = 86.

participant No. 3024 matched successive responses on at least four attributes (i.e., Cluster 1, "cow, horse"; Cluster 2, "duck, geese"; Cluster 3, "deer, moose"; Cluster 4, "koala bear, panda bear, zebra, giraffe, elephant"). This index was developed to measure the executive control ability that is required to search and shift into multiple semantic fields.

*3. Average cluster size (SIZE).* The SIZE is the total number of words in the cluster divided by the number of clusters (NC participant No. 3024, 11/4 = 2.75). A low score on this index may be caused by degraded semantic knowledge.

*4. Percent of the total output in cluster (PERCENT).* The PERCENT is the number of words in the cluster divided by the number of total correct responses (NC participant No. 3024, 11/14 = 79%). As with the AI, the PERCENT index was designed to measure the semantic interrelatedness between responses. Because only exemplars that are highly related or are associated were coded as within a cluster, a high score on this index is thought to reflect relatively intact associations between concepts in semantic knowledge.

As in the letter WLG task, errors were also scored. The number of perseverations, nonspecific responses (i.e., instances where participants responded "fish," "insects," "birds," etc.) and category violations errors (e.g., "chair") were totaled. Phonemic clusters were also tallied, that is, instances where consecutive responses rhyme or share the same first or last consonant (e.g., *cat* and *rat, bear* and *buffalo*).

### Neuropsychological Assessment

In addition to taking tests of letter and category WLG, participants took the 60-item version of the BNT (Kaplan, Goodglass, & Weintraub, 1983), the WMS–MC subtest (Wechsler, 1945), and the Goldberg GST (Goldberg & Tucker, 1979). The dependent variable for the BNT was the number of items correctly named. For the WMS–MC subtest, the 9-point scoring system as described in the test manual was the dependent variable. On the GST, participants were asked to draw or to write easily recognizable geometric objects, shapes, and letters. At various times throughout the test, participants were required to switch their mode of output, that is, instead of *drawing* geometric shapes such as circles, squares, and triangles, participants were required to *write* sentences using the words "circle, square, and triangle," and so on. The dependent variable was the total number of perseverations made throughout the test.

## Results

The effect of group on WLG task performance was analyzed with a series of univariate analyses of variance (ANOVAs), multivariate analyses of variance (MANOVAs), and chi-square analyses. In these analyses, the variable group (i.e., AD, IVD, NC) was the independent variable, and all eight of the measures derived from both WLG tasks were the dependent variables. Because there were between-group differences in education and the GDS, these variables were covaried in all analyses. The Bonferroni correction was applied to all post hoc analyses depending on the number of variables contained within each univariate or multivariate ANOVA.

Output from the two WLG tasks was analyzed with a Task (letter vs. animal) × Group (AD, IVD, vs. NC) repeated measures ANOVA. To directly equate performance on the two WLG tasks, we divided output on the letter WLG by three. This analysis yielded a main effect for group, $F(2, 93) = 138.34, p < .001$, and a significant Group × Task interaction, $F(2, 93) = 7.72$, $p < .001$. NC participants produced significantly more total responses than AD and IVD participants on both the letter and category WLG tasks at or above the $p < .001$ level (see Table 3). Although between-group analyses found no difference for the number of total responses among the AD and IVD groups on the animal WLG, AD participants produced significantly more responses on the letter WLG test than IVD participants, $t(66) = 4.06$, $p < .001$. Within-group analyses of the two WLG tasks indicated that AD participants tended to produce fewer responses on the animal WLG as compared to the letter WLG task, $t(39) = 2.24, p < .031$. However, IVD and NC participants generally produced more responses on the animal WLG task as compared to the letter WLG task: IVD, $t(27) = 3.50, p < .002$; NC, $t(30) = 2.39, p < .023$.

Because the CLUSTER index is not corrected for total

Table 3
*Means and Standard Deviations for Letter and Animal Word List Generation (WLG) Tasks*

| Measure | AD *M* | AD *SD* | IVD *M* | IVD *SD* | NC *M* | NC *SD* |
|---|---|---|---|---|---|---|
| Total number of responses | | | | | | |
| Letter WLG | 23.3 | 9.6 | 15.0 | 6.2 | 45.3 | 12.9 |
| Category (animal WLG) | 6.7 | 2.5 | 6.9 | 2.7 | 17.7 | 4.7 |
| Indices compiled from the animal WLG task | | | | | | |
| AI | 2.7 | .85 | 3.3 | 0.84 | 3.4 | 0.50[b] |
| SUPER-AI | 2.2 | .67 | 2.6 | 0.62 | 2.6 | 0.33[b] |
| SUB-AI | 0.43 | 0.30 | 0.68 | 0.33 | 0.81 | 0.32[b] |
| Number of clusters | 1.4 | 1.0 | 2.2 | 1.0 | 4.9 | 1.5[a] |
| Cluster size | 1.9 | 0.94 | 2.3 | 0.42 | 2.7 | 0.56[a] |
| Percent in cluster | 45.4 | 27.1 | 72.6 | 22.8 | 75.6 | 16.8[b] |

*Note.* AD = Alzheimer's disease; IVD = ischemic vascular disease; NC = normal control; AI = total association index; SUPER-AI = superordinate association index; SUB-AI = subordinate association index.
[a]AD < IVD < NC. [b]AD < IVD = NC.

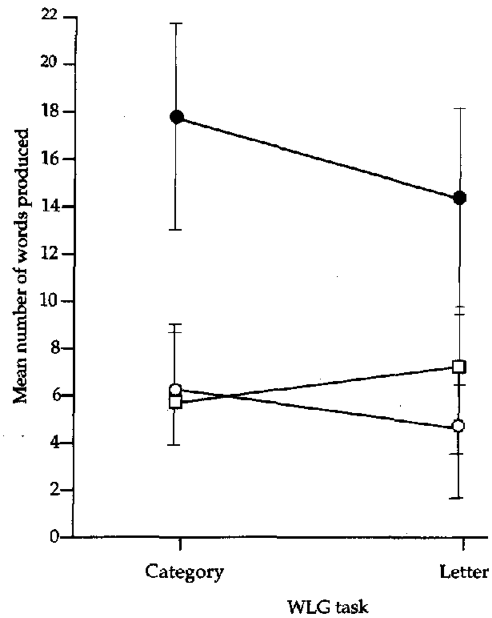


*Figure 1.* Output on letter and category (animal) word list generation (WLG) tasks for Alzheimer's disease (AD; squares), ischemic vascular dementia (IVD; open circles), and normal control (NC; solid circles) participants.

output, of course the NC group is expected to outperform the AD and IVD groups on this measure. This measure was analyzed separately with a single ANOVA. As expected, a highly significant effect of group was obtained, $F(2, 92) = 60.11$, $p < .001$. The NC group outperformed the AD and IVD groups at or above $p < .001$. Contrary to our expectation, however, IVD participants produced more clusters than AD participants, $t(66) = 2.96$, $p < .004$.

The effect of group on the TOTAL-AI was assessed with a one-way ANOVA. The analysis yielded a significant effect for group, $F(2, 92) = 8.94$, $p < .001$. Follow-up analyses indicated that the IVD group outperformed the AD group, $t(66) = 3.13$, $p < .003$; there was no difference between the IVD and NC groups; and the AD group obtained a lower score than the NC group, $t(69) = 4.22$, $p < .001$. The SUPER-AI and SUB-AI were analyzed together in a single MANOVA, and a significant multivariate effect for group was found, $F(4, 184) = 5.64$, $p < .001$. Both univariate ANOVAs were significant, $F(2, 92) = 4.98$, $p < .009$, $F(2, 83) = 9.23$, $p < .001$, for SUPER-AI and SUB-AI, respectively. For the SUPER-AI, follow-up comparisons indicated that the IVD group obtained a slightly better score than the AD group, $t(66) = 2.49$, $p < .019$; there was no difference between the NC and IVD groups; and the NC group significantly outperformed the AD group, $t(69) = 2.77$, $p < .007$. For the SUB-AI, the IVD group, again, outperformed the AD group, $t(57) = 2.93$, $p < .005$; there was no difference between the IVD and NC groups; and the NC group obtained a higher score than the AD group, $t(63) = 4.98$, $p < .001$.

The SIZE and PERCENT indices were analyzed together in a single MANOVA, and a significant multivariate effect for group was found, $F(4, 180) = 9.90$, $p < .001$. Both univariate analyses were also significant, $F(2, 92) = 10.36$, $p < .001$, $F(2, 92) = 17.04$, $p < .001$, for SIZE and PERCENT, respectively. On the SIZE index, the NC group outperformed the AD and IVD groups at or above $p < .001$. In addition, there was a trend for IVD participants to produce larger clusters (SIZE) than AD participants, $t(66) = 1.97$, $p < .053$. On the PERCENT index, a higher percentage of total responses of the IVD participants was within a cluster in comparison to AD participants, $t(66) = 4.33$, $p < .001$. There was no difference between the IVD and NC groups. The AD group obtained a lower score on this measure than the NC group, $t(69) = 5.53$, $p < .001$.

Because individual participants tended to make only a few perseverations, nonspecific responses (e.g., "fish," "birds"), extracategory intrusions, or phonemic clusters on the letter or category WLG task, chi-square analyses were used to assess between-group differences. No between-group differences were found on either WLG task.

Correlations were calculated only for the AD and IVD groups between SUPER-AI, SUB-AI, PERCENT, SIZE, and CLUSTER indices and performance on the BNT, WMS–MC subtest, and the GST. For the AD group, significant correlations were found such that as scores on the BNT increased, participants obtained higher scores on the SUB-AI, SIZE, and CLUSTER indices (SUB-AI, $r = .43$, $p < .002$; SIZE, $r = .38$, $p < .009$; CLUSTER, $r = .44$, $p < .002$). Correlational analyses involving the WMS–MC subtest and GST were not significant. A different profile emerged for the IVD group such that as participants made *more* perseverations on the GST, the numbers of CLUSTERS on the animal WLG task *declined* ($r = -.43$, $p < .023$). None of the correlations involving the WMS–MC subtest or BNT reached significance.

## Discussion

AD and cerebrovascular dementia are the two most prevalent dementing illnesses (Katzman & Kawas, 1994); however, there is a paucity of research findings that can differentiate between these two disorders. One reason for this is that there is a considerable degree of heterogeneity among the vascular dementias (see Wallin & Blennow, 1993, for a review). In the present research, the vascular dementing syndrome we studied was primarily associated with subcortical white matter alterations. The purpose of the present study was to investigate the underlying mechanisms for the reduced output on the animal WLG task among participants with this subtype of IVD.

In an attempt to gain a better understanding of the nature of the deficit on category WLG tasks in the IVD group, phonemic and semantic WLG tasks were compared. Within-group comparisons showed that IVD and AD participants produced opposite profiles with respect to the number of responses generated on each WLG task. IVD and NC participants produced more responses on the animal as compared to the letter WLG task, whereas AD participants produced the opposite profile. In addition, between-group analyses indicated that IVD participants generated fewer words than AD participants on the letter WLG task. Both findings are similar to past studies showing that HD and PSP participants, whose dementia has traditionally been associated with subcortical pathology, perform worse on phonemic WLG tasks in comparison to AD participants (Hodges, Salmon, & Butters, 1990; Monsch et al., 1994; Rosser & Hodges, 1994). This pattern of performance has been interpreted as evidence for greater search and retrieval deficits among participants whose dementia is associated with subcortical alterations but greater semantic knowledge deficits in AD (Rosser & Hodges, 1994).

The CLUSTER index was developed in an attempt to assess participants' ability to shift mental set in their search for information. Because past research has shown that IVD participants demonstrate a disproportionate degree of impairment in executive control as compared to other domains of cognitive functioning, our second prediction was that IVD participants would produce fewer clusters than AD participants. However, the results we obtained were inconsistent. Contrary to our expectation, IVD participants did not produce fewer numbers of CLUSTERS in comparison to AD participants. Yet, the correlational analyses that were carried out indicated that, as IVD participants made *more* perseverations on the GST, that is, demonstrating *greater* problems in shifting mental set, their output on the animal WLG task was organized into *fewer* clusters. By contrast, no significant correlations were found between the animal WLG indices and tests of executive control functions for the AD group. Thus, the degree to which deficits in shifting mental set contribute to the reduced output on the animal WLG task in IVD is unclear and requires more research.

IVD participants differed in comparison to NC participants only in terms of the SIZE of their clusters. Originally, we conceived of the SIZE index as a means to measure semantic rather than executive functions. However, within the context of the IVD participants' high AI scores, their low SIZE index in relation to NC participants may reflect a combination of deficient retrieval strategies and difficulty in maintaining response set secondary to impairment in executive control.

Our third prediction was that IVD participants would demonstrate preservation of semantic knowledge comparable to the NC participants. As noted earlier, there was no difference in total output on the animal WLG task between the AD and IVD groups. However, when the compilation of the TOTAL-AI, SUB-AI, SUPER-AI, and PERCENT indices were controlled for output, IVD participants produced higher scores than AD participants. Moreover, there were no differences on these measures between the IVD and NC groups. Thus, despite the fact that IVD and AD participants produced an equal absolute number of responses on the animal WLG task, NC and IVD participants, unlike AD participants, produced responses that were highly semantically related.

By contrast, AD participants produced TOTAL-AI, SUB-AI, SUPER-AI, and PERCENT measures that were significantly lower than IVD and NC participants. The reason for this was that AD participants were generally unable to generate successive responses that were rich in very specific, subordinate attributes. This suggests that AD participants lose the subordinate, defining features of exemplars within semantic categories, and the remaining general or superordinate features are not sufficient to organize semantic information meaningfully.

In light of the AD participants' very low AI scores, their low scores on the SIZE and PERCENT indices suggest that the output of AD participants were not organized into semantic clusters. This is contrary to the output produced by IVD and NC participants and implies that AD participants do not perform the animal WLG task in the same manner Gruenewald and Lockhead (1980) proposed normal participants execute the task. AD participants are not generating exemplars from subordinate semantic fields within the larger category of animals, because the knowledge necessary to organize exemplars in an optimal, semantically meaningful fashion is lost or degraded. Instead, for AD participants, both related and unrelated exemplars are equally activated during the WLG tasks and are equally likely to be generated following a given response. By contrast, our data indicate that IVD participants attempt to perform the animal WLG task in a manner more similar to NC participants.

These findings were supported by correlational analyses performed between the category WLG indices and the BNT. For the AD group, significant relationships were found between animal WLG indices that measure the strength of association between consecutive responses and the BNT, a test related to semantic functioning. Thus, to the extent that AD participants obtained *better* scores on the SUB-AI and SIZE indices, their corresponding scores on the BNT *increased.* None of the correlations between the animal WLG indices and the BNT were significant for the IVD group.

Several theoretical positions have been proposed that attempt to explain the differing patterns of performance on letter and category WLG tasks in dementia. The degradation hypothesis suggests that participants experience a deterioration of the actual structure of semantic knowledge such that the associations between concepts and the constituent attributes that truly define the specific nature of objects are lost or degraded (Chertkow & Bub, 1990; Hodges, Salmon, & Butters, 1992; Martin, 1992). Alternatively, the disrupted access hypothesis holds that semantic knowledge is essentially intact but that participants are unable to either access or to use their semantic knowledge appropriately (Bonilla & Johnson, 1995; Johnson, Hermann, & Bonilla, 1995; Hartman, 1991; Nebes, 1989; Nebes, Brady, & Huff, 1989; Nebes, Martin, & Horn, 1984).

We feel that the test scores produced by the AD participants tend to support the degradation hypothesis. We acknowledge, however, that the primary focus of this research did not directly address the nature of the semantic knowledge deficit in AD; thus, other explanations are certainly possible. With respect to the IVD participants, performance on the animal WLG task appears to be most consistent with the disrupted access hypothesis. Our data may be interpreted to suggest that disrupted access to semantic knowledge in IVD may be due to retrieval deficits. The evidence we found suggesting that IVD participants' reduced output on the animal WLG is due to executive control deficits, such as difficulty in maintaining and shifting mental set, was equivocal. Indeed, it is possible that other additional cognitive impairments may contribute to the reduced output of the IVD participants. For example, cognitive slowing, in general, is often associated with dementing illnesses involving subcortical neuropathology and may also be at least partially responsible for the reduced output of IVD participants on semantic WLG tasks.

In sum, our findings indicate that a more detailed analysis of the output produced from the animal WLG task can show material differences between participants with AD and IVD associated with periventricular and deep white matter alterations. We believe that the performance of our AD participants on the indices described previously is very likely caused by an overall dissolution of semantic knowledge, whereas the difficulties exhibited by the IVD participants are due to deficits in the retrieval of information. The retrieval deficits of the IVD participants may be due, in part, to impairment in executive control such that these participants have difficulty in maintaining and shifting mental set to search for and retrieve semantic information efficiently.

## References


Austrom, M. G., Thompson, R. F., Hendrie, H. C., Norton, J., Farlow, M. R., Edwards, M. K., & Dean, R. (1990). Foci of increased T2 signal intensity in MR images of healthy elderly subjects: A follow-up study. *Journal of the American Geriatric Society, 38,* 1133–1138.

Bar, A., Benedict, R., Tune, L., & Brand, J. (1992). Neuropsychological differentiation of Alzheimer's disease from vascular dementia. *International Journal of Geriatric Psychiatry, 7,* 621–627.

Bayles, K. A., Trosset, M. W., Tomoeda, C. K., Montgomery, E. B., & Wilson, J. (1993). Generative naming in Parkinson disease patients. *Journal of Clinical and Experimental Neuropsychology, 15,* 547–562.

Beatty, W. W., Monson, N., & Goodkin, D. E. (1989). Access to semantic memory in Parkinson's disease and multiple sclerosis. *Journal of Geriatric Psychiatry and Neurology, 2,* 153–162.

Beatty, W. W., Staton, R. D., Weir, W. S., Monson, N., & Whitaker, H. A. (1989). Cognitive disturbances in Parkinson's disease. *Journal of Geriatric Psychiatry and Neurology, 2,* 22–33.

Bernard, B. A., Wilson, R. S., Gilley, D. W., Bennett, D. A., & Fox, J. H. (1992). Memory failure in Binswanger's disease and Alzheimer's disease. *The Clinical Neuropsychologist, 6,* 230–240.

Binetti, G., Magni, E., Cappa, S. F., Padovani, A., Bianchetti, A., & Trabucchi, M. (1995). Semantic memory in Alzheimer's disease: An analysis of semantic fluency. *Journal of Clinical and Experimental Neuropsychology, 17,* 82–89.

Bogdanoff, B., Bonavita, J., Libon, D. J., Cass, P., & Cloud, B. S. (1994, May) *Clinical and neuropsychological correlates of ischaemic vascular dementia.* Poster presented at the 46th annual meeting of the American Academy of Neurology, Washington, DC.

Bonilla, J. L., & Johnson, M. K. (1995). Semantic space in Alzheimer's disease. *Neuropsychology, 9,* 345–353.

Boone, K., Miller, B. L., Lesser, I. M., Mehringer, C. M., Hill-Gutierrez, E., Goldberg, M. A., & Berman, N. G. (1992). Neuropsychological correlates of white-matter lesions in healthy elderly subjects. *Archives of Neurology, 49,* 549–554.

Breteler, M. M. B., van Swieten, J. C., Bots, M. L., Grobbee, D. E., Claus, J. J., van der Hout, J. H. W., van Harskamp, F., Tanghe, H. L. J., de Jong, P. T. V. M., van Gijn, J., & Hoffman, A. (1994). Cerebral white matter lesions, vascular risk factors, and cognitive functioning in a population-based study: The Rotterdam study. *Neurology, 44,* 1246–1252.

Butters, N., Granholm, E., Salmon, D. P., Grant, I., & Wolfe, J. (1987). Episodic and semantic memory: A comparison of amnesic and demented patients. *Journal of Clinical and Experimental Neuropsychology, 9,* 479–497.

Chan, A. S., Butters, N., Paulsen, J. S., Salmon, D. P., Swenson, M. R., & Maloney, L. T. (1993). An assessment of semantic networks in patients with Alzheimer's disease. *Journal of Cognitive Neuroscience, 5,* 254–261.

Chertkow, H., & Bub, D. (1990). Semantic memory loss in dementia of the Alzheimer's type: What do various measures measure? *Brain, 113,* 397–417.

Chui, H. C., Victoroff, J. I., Margolin, D., Jaugust, W., Shankle, R., & Katzman, R. (1992). Criteria for the diagnosis of ischemic vascular dementia proposed by the State of California Alzheimer's Disease Diagnostic and Treatment Centers. *Neurology, 42,* 473–480.

Fischer, P., Gatterer, G., Marterer, A., & Danielczyk, W. (1988). Nonspecificity of semantic impairment in dementia of the Alzheimer's type. *Archives of Neurology, 45,* 1341–1343.

Folstein, M. F., Folstein, S. E., & McHugh, P. R. (1975). Mini-Mental State: A practical method for grading the cognitive state of patients for the clinician. *Journal of Psychiatric Research, 12,* 189–198.

Fukuda, H., Kobayashi, S., Okada, F., & Tsunematsu, T. (1990). Frontal white matter lesions and dementia in lacunar infarction. *Stroke, 21,* 1143–1149.

Goldberg, E., & Tucker, D. (1979). Motor perseveration and long-term memory for visual forms. *Journal of Clinical Neuropsychology, 1,* 273–288.

Gruenewald, P. J., & Lockhead, G. R. (1980). The free recall of category examples. *Journal of Experimental Psychology: Human Learning and Memory, 6,* 225–240.

Gupta, S. R., Naheedy, M. H., Young, J. C., Ghobrial, F. A., Rubino, F. A., & Hindo, W. (1988). Periventricular white matter changes and dementia: Clinical, neuropsychological, radiological, and pathological findings. *Archives of Neurology, 45,* 637–641.

Hartman, M. D. (1991). The use of semantic knowledge in Alzheimer's disease: Evidence for impairments of attention. *Neuropsychologia, 29,* 213–228.

Hodges, J., Salmon, D. P., & Butters, N. (1990). Differential impairment in Alzheimer's and Huntington's diseases: A control prospective study. *Journal of Neurology, Neurosurgery and Psychiatry, 53,* 1089–1095.

Hodges, J. R., Salmon, D. P., & Butters, N. (1992). Semantic memory impairment in Alzheimer's disease: Failure of access or degraded knowledge? *Neuropsychologia, 30,* 301–314.

Ishii, N., Nishihara, Y., & Imamura, T. (1986). Why do frontal lobe symptoms predominate in vascular dementia with lacunas? *Neurology, 36,* 340–345.

Johnson, M. K., Hermann, A. M., & Bonilla, J. L. (1995). Semantic relations and Alzheimer's disease: typicality and direction of testing. *Neuropsychology, 9,* 529–536.

Kaplan, E., Goodglass, H., & Weintraub, S. (1983). *The Naming Test* (2nd ed.). Philadelphia: Lea & Febiger.

Katzman, R., & Kawas, C. H. (1994). The epidemiology of dementia and Alzheimer's disease. In R. D. Terry, R. Katzman,

& K. L. Bick (Eds.), *Alzheimer's disease* (pp. 105–122). New York: Lippincott-Raven.

Kertesz, A., Polk, M., & Carr, T. (1990). Cognition and white matter changes on magnetic resonance imaging. *Archives of Neurology, 47,* 387–391.

Libon, D. J., Mattson, R., Glosser, G., Kaplan, E., Malamut, B. L., Sands, L. P., Swenson, R., & Cloud, B. S. (1996). A nine word dementia version of the California Verbal Learning Test. *The Clinical Neuropsychologist, 10,* 237–244.

Martin, A. (1992). Degraded knowledge representation in patients with Alzheimer's disease: Implications for models of semantic and repetition priming. In L. R. Squire & N. Butters (Eds.), *Neuropsychology of memory* (2nd ed., pp. 220–232). New York: Guilford Press.

Martin, A., & Fedio, P. (1983). Word production and comprehension in Alzheimer's disease: A breakdown of semantic knowledge. *Brain and Language, 19,* 124–141.

Matsubayashi, K., Shimada, K., Kawamoto, A., & Ozawa, T. (1992). Incidental brain lesions on magnetic resonance imaging and neurobehavioral functions in the apparently healthy. *Stroke, 23,* 175–180.

McKhann, G., Drachman, D., Folstein, M., Katzman, R., Price, D., & Stadlan, E. M. (1984). Clinical diagnosis of Alzheimer's disease: Report of the NINCDS-ADRDA work group under the auspices of the Department of Health and Human Services Task Force on Alzheimer's Disease. *Neurology, 34,* 939–944.

Mickanin, J., Grossman, M., Onishi, K., Auriacombe, S., & Clark, C. (1994). Verbal and non-verbal fluency in patients with probable Alzheimer's disease. *Neuropsychology, 8,* 385–394.

Milberg, W., & Albert, M. (1989). Cognitive differences between patients with progressive supranuclear palsy and Alzheimer's disease. *Journal of Clinical and Experimental Neuropsychology, 11,* 605–614.

Monsch, A. U., Bondi, M. W., Butters, N., Paulsen, J. S., Salmon, D. P., Brugger, P., & Swenson, M. R. (1994). A comparison of category and letter in Alzheimer's and Huntington's disease. *Neuropsychology, 8,* 25–30.

Nebes, R. D. (1989). Semantic memory in Alzheimer's disease. *Psychological Bulletin, 106,* 377–394.

Nebes, R. D., Brady, C. B., & Huff, F. J. (1989). Automatic and attentional mechanisms of semantic priming in Alzheimer's disease. *Journal of Clinical and Experimental Neuropsychology, 11,* 219–230.

Nebes, R. D., Martin, D. C., & Horn, L. C. (1984). Sparing of semantic memory in Alzheimer's disease. *Journal of Abnormal Psychology, 93,* 321–330.

Ober, B. A., Dronkers, N. F., Koss, E., Delis, D. C., & Friedland, R. P. (1986). Retrieval from semantic memory in Alzheimer type dementia. *Journal of Clinical and Experimental Neuropsychology, 8,* 75–92.

Podell, K., Lamar, M., Resh, R., Libon, D. J., & Kennedy, C. (1996). *Perseverative behavior in Alzheimer's disease and subcortical ischaemic vascular dementia.* Poster presented at the 16th annual meeting of the National Academy of Neuropsychology, New Orleans, LA.

Randolph, C., Braun, A. R., Goldberg, T. E., & Chase, T. (1993). Semantic fluency in Alzheimer's, Parkinson's and Huntington's disease: Dissociation of storage and retrieval failures. *Neuropsychology, 7,* 82–88.

Rosen, W. (1980). Verbal fluency in aging and dementia. *Journal of Clinical Neuropsychology, 2,* 135–146.

Rosser, A., & Hodges, J. R. (1994). Initial letter and semantic category fluency in Alzheimer's disease, Huntington's disease, and progressive supranuclear palsy. *Journal of Neurology, Neurosurgery and Psychiatry, 57,* 1389–1394.

Schmidt, R., Fazekas, F., Offenbacher, H., Dusek, T., Zach, E., Reinhart, B., Grieshofer, P., Freidl, W., Eber, B., Schumacher, M., Koch, M., & Lechner, H. (1993). Neuropsychological correlates of MRI white matter hyperintensities: A study of 150 normal volunteers. *Neurology, 43,* 2490–2494.

Sims, R. W. (1980). *Animal identification reference guide* (Vols. 1–3). New York: Wiley.

Troster, A. I., Salmon, D. P., McCullough, D., & Butters, N. (1989). A comparison of category fluency deficits associated with Alzheimer's and Huntington's disease. *Brain and Language, 37,* 500–513.

Villardita, C. (1993). Alzheimer's disease compared with cerebrovascular dementia: Neuropsychological similarities and differences. *Acta Neurologica Scandinavica, 87,* 299–308.

Wallin, A., & Blennow, K. (1993). Heterogeneity of vascular dementia: Mechanisms and subgroups. *Journal of Geriatric Psychiatry and Neurology, 6,* 177–188.

Wechsler, D. (1945). A standardized memory test for clinical use. *Journal of Psychology, 19,* 87–95.

Weingartner, H. J., Kawas, C., Rawlings, R., & Shapiro, M. (1993). Changes in semantic memory in early stages of Alzheimer's disease patients. *The Gerontologist, 33,* 637–643.

Yesavage, J. (1986). The use of self-rating depression scales in the elderly. In L. W. Poon, (Ed.), *Handbook of clinical memory assessment of older adults* (pp. 213–217). Washington, DC: American Psychological Association.

Ylikoski, R., Ylikoski, A., Erkinjuntti, T., Sulkava, R., Raininko, R., & Tilvis, R. (1993). White matter changes in healthy elderly persons correlate with attention and speed of mental processing. *Archives of Neurology, 50,* 818–824.

*(Appendix follows)*

## Appendix

### Animal Word List

| Item | Size | Location | Class | Order | Diet | Habitat |
|---|---|---|---|---|---|---|
| Aardvark | Small | Foreign | Mammal | Myrmecophagidae | Carnivore | Widespread |
| Alligator | Big | Native | Reptile | Crocodilia | Carnivore | Water |
| Anteater | Small | Foreign | Mammal | Myrmecophagidae | Carnivore | African/jungle |
| Antelope | Big | Native | Mammal | Bovine | Herbivore | Prairie |
| Ants | Small | Native | Insect | Crawling insects | Omnivore | Widespread |
| Ape | Big | Foreign | Mammal | Primate | Herbivore | African/jungle |
| Baboon | Big | Foreign | Mammal | Primate | Herbivore | African/jungle |
| Badger | Small | Native | Mammal | Rodenta and related | Carnivore | Widespread |
| Bat | Small | Local | Mammal | Rodenta and related | Carnivore | Widespread |
| Bear | Big | Native | Mammal | Ursine | Omnivore | Forest |
| Beaver | Small | Native | Mammal | Rodenta and related | Herbivore | Water |
| Bees | Small | Native | Insect | Flying insect | Herbivore | Widespread |
| Beetle | Small | Native | Insect | Crawling insect | Omnivore | Widespread |
| Bison | Big | Native | Mammal | Bovine | Herbivore | Prairie |
| Blackbird | Small | Native | Bird | Flying bird | Omnivore | Widespread |
| Bluejay | Small | Native | Bird | Flying bird | Omnivore | Widespread |
| Boar | Big | Native | Mammal | Porcine | Omnivore | Widespread |
| Bobcat | Small | Native | Mammal | Feline | Carnivore | Widespread |
| Buffalo | Big | Native | Mammal | Bovine | Herbivore | Prairie |
| Bull | Big | Native | Mammal | Bovine | Herbivore | Widespread |
| Camel | Big | Foreign | Mammal | Artiodactyla | Herbivore | Farm |
| Canary | Small | Foreign | Bird | Flying bird | Herbivore | Pet |
| Cardinal | Small | Native | Bird | Flying bird | Omnivore | Widespread |
| Cat | Small | Native | Mammal | Feline | Carnivore | Pet |
| Cattle | Big | Native | Mammal | Bovine | Herbivore | Farm |
| Cheetah | Small | Foreign | Mammal | Feline | Carnivore | African/jungle |
| Chickadee | Small | Native | Bird | Flying bird | Omnivore | Widespread |
| Chicken | Small | Native | Bird | Fowl | Herbivore | Farm |
| Chipmunk | Small | Native | Mammal | Rodenta and related | Omnivore | Forest |
| Cougar | Big | Native | Mammal | Feline | Carnivore | Widespread |
| Crab | Small | Native | Fish | Crustacea | Omnivore | Water |
| Crocodile | Big | Native | Reptile | Crocodilia | Carnivore | Water |
| Crow | Small | Native | Bird | Flying bird | Omnivore | Widespread |
| Deer | Big | Native | Mammal | Cervidae | Herbivore | Forest |
| Doe | Big | Native | Mammal | Cervidae | Herbivore | Forest |
| Dog | Small | Native | Mammal | Canine | Carnivore | Pet |
| Dolphin | Big | Native | Mammal | Cetacea | Carnivore | Water |
| Donkey | Big | Native | Mammal | Equine | Herbivore | Farm |
| Duck | Small | Native | Bird | Fowl | Omnivore | Farm |
| Eagle | Big | Native | Bird | Flying bird | Carnivore | Widespread |
| Eel | Small | Native | Fish | Squamata | Carnivore | Water |
| Elephant | Big | Foreign | Mammal | Pachyderm | Herbivore | African/jungle |
| Elk | Big | Native | Mammal | Cervidae | Herbivore | Forest |
| Ferret | Small | Native | Mammal | Rodenta and related | Omnivore | Forest |
| Finch | Small | Native | Bird | Flying bird | Herbivore | Widespread |
| Fleas | Small | Local | Insect | Land insect | Omnivore | Widespread |
| Flies | Small | Local | Insect | Flying insect | Omnivore | Widespread |
| Fox | Small | Native | Mammal | Canine | Carnivore | Forest |
| Frog | Small | Local | Amphib | Squamata | Carnivore | Water |
| Geese | Small | Native | Bird | Fowl | Herbivore | Farm |
| Gerbil | Small | Native | Mammal | Rodenta and related | Herbivore | Pet |
| Guinea pig | Small | Foreign | Mammal | Rodenta and related | Herbivore | Pet |
| Giraffe | Big | Foreign | Mammal | Artiodactyla | Herbivore | African/jungle |
| Goat | Small | Native | Mammal | Bovine | Herbivore | Farm |
| Gopher | Small | Native | Mammal | Rodenta and related | Herbivore | Widespread |
| Gorilla | Big | Foreign | Mammal | Primate | Herbivore | African/jungle |
| Groundhog | Small | Native | Mammal | Rodenta and related | Omnivore | Forest |
| Hamster | Small | Native | Mammal | Rodenta and related | Herbivore | Pet |
| Hawk | Big | Native | Bird | Flying bird | Carnivore | Widespread |
| Hedgehog | Small | Foreign | Mammal | Rodenta and related | Carnivore | Widespread |
| Hermit crab | Small | Native | Fish | Crustacea | Omnivore | Water |
| Heron | Small | Native | Bird | Flying bird | Carnivore | Water |
| Herring | Small | Native | Fish | Salt fish | Carnivore | Water |
| Hippopotamus | Big | Foreign | Mammal | Pachyderm | Herbivore | Water |
| Horse | Big | Native | Mammal | Equine | Herbivore | Farm |

Appendix (*Continued*)

Animal Word List

| Item | Size | Location | Class | Order | Diet | Habitat |
|---|---|---|---|---|---|---|
| Horseshoe crab | Small | Native | Fish | Crustacea | Omnivore | Water |
| Hound | Small | Native | Mammal | Canine | Carnivore | Pet |
| Hyena | Small | Foreign | Mammal | Canine | Carnivore | African/jungle |
| Jackal | Small | Foreign | Mammal | Canine | Carnivore | African/jungle |
| Jaguar | Big | Native | Mammal | Feline | Carnivore | African/jungle |
| Kangaroo | Big | Foreign | Mammal | Marsupial | Herbivore | Australia |
| Kitty | Small | Native | Mammal | Feline | Carnivore | Pet |
| Koala | Small | Foreign | Mammal | Ursine | Herbivore | Australia |
| Lamb | Small | Native | Mammal | Bovine | Herbivore | Farm |
| Lark | Small | Native | Bird | Flying bird | Omnivore | Widespread |
| Leopard | Big | Foreign | Mammal | Feline | Carnivore | African/jungle |
| Lion | Big | Foreign | Mammal | Feline | Carnivore | African/jungle |
| Lizard | Small | Native | Reptile | Squamata | Carnivore | Widespread |
| Llama | Big | Foreign | Mammal | Artiodactyla | Herbivore | Farm |
| Lobster | Small | Native | Fish | Crustacea | Omnivore | Water |
| Lynx | Small | Native | Mammal | Feline | Carnivore | Widespread |
| Man | Big | Native | Mammal | Primate | Omnivore | Widespread |
| Mink | Small | Native | Mammal | Rodenta and related | Carnivore | Water |
| Monkey | Small | Foreign | Mammal | Primate | Herbivore | African/jungle |
| Moose | Big | Native | Mammal | Cervidae | Herbivore | Forest |
| Mouse | Small | Native | Mammal | Rodenta and related | Omnivore | Widespread |
| Mule | Big | Native | Mammal | Equine | Herbivore | Farm |
| Muskrat | Small | Native | Mammal | Rodenta and related | Omnivore | Water |
| Newt | Small | Native | Fish | Squamata | Carnivore | Water |
| Ocelot | Small | Foreign | Mammal | Feline | Carnivore | Widespread |
| Octopus | Small | Native | Fish | Mollusk | Carnivore | Water |
| Okapi | Small | Foreign | Mammal | Artiodactyla | Herbivore | African/jungle |
| Opossum | Small | Native | Mammal | Marsupial | Omnivore | Forest |
| Ostrich | Big | Foreign | Bird | Land bird | Omnivore | African/jungle |
| Otter | Small | Native | Mammal | Rodenta and related | Carnivore | Water |
| Ox | Small | Native | Mammal | Bovine | Herbivore | Farm |
| Oyster | Small | Native | Fish | Mollusk | Omnivore | Water |
| Panda | Small | Foreign | Mammal | Ursine | Herbivore | African/jungle |
| Panther | Big | Foreign | Mammal | Feline | Carnivore | African/jungle |
| Parakeet | Small | Foreign | Bird | Flying bird | Herbivore | Pet |
| Parrot | Small | Foreign | Bird | Flying bird | Herbivore | Pet |
| Peacock | Small | Foreign | Bird | Fowl | Omnivore | African/jungle |
| Pelican | Small | Native | Bird | Flying bird | Carnivore | Water |
| People | Big | Native | Mammal | Primate | Omnivore | Widespread |
| Pig | Small | Native | Mammal | Porcine | Omnivore | Farm |
| Pigeon | Small | Native | Bird | Flying bird | Herbivore | Widespread |
| Platypus | Small | Foreign | Mammal | Marsupial | Carnivore | Australia |
| Polar bear | Big | Foreign | Mammal | Ursine | Carnivore | Water |
| Pony | Big | Native | Mammal | Equine | Herbivore | Farm |
| Porcupine | Small | Native | Mammal | Rodenta and related | Omnivore | Widespread |
| Prairie dog | Small | Native | Mammal | Rodenta and related | Herbivore | Prairie |
| Puma | Big | Native | Mammal | Feline | Carnivore | Widespread |
| Python | Small | Foreign | Reptile | Squamata | Carnivore | African/jungle |
| Rabbit | Small | Native | Mammal | Rodenta and related | Herbivore | Forest |
| Raccoon | Small | Native | Mammal | Rodenta and related | Omnivore | Forest |
| Rat | Small | Native | Mammal | Rodenta and related | Omnivore | Widespread |
| Raven | Small | Native | Bird | Flying bird | Omnivore | Widespread |
| Reindeer | Big | Foreign | Mammal | Cervidae | Herbivore | Forest |
| Rhino | Big | Foreign | Mammal | Pachyderm | Herbivore | African/jungle |
| Roaches | Small | Native | Insect | Crawling insect | Herbivore | Widespread |
| Robin | Small | Native | Bird | Flying bird | Omnivore | Widespread |
| Rooster | Small | Native | Bird | Fowl | Herbivore | Farm |
| Sable | Small | Native | Mammal | Rodenta and related | Omnivore | Forest |
| Salamander | Small | Native | Fish | Squamata | Carnivore | Water |
| Salmon | Small | Native | Fish | Salt fish | Carnivore | Water |
| Sea lion | Big | Native | Mammal | Sea mammal | Carnivore | Water |
| Seal | Big | Native | Mammal | Sea mammal | Carnivore | Water |
| Shark | Big | Native | Fish | Salt fish | Carnivore | Water |
| Sheep | Small | Native | Mammal | Bovine | Herbivore | Farm |
| Skunk | Small | Native | Mammal | Rodenta and related | Omnivore | Forest |

Appendix (*Continued*)

Animal Word List

| Item | Size | Location | Class | Order | Diet | Habitat |
|---|---|---|---|---|---|---|
| Snails | Small | Native | Insect | Mollusk | Herbivore | Widespread |
| Snake | Small | Native | Reptile | Squamata | Carnivore | Widespread |
| Spider | Small | Native | Insect | Arachniae | Omnivore | Widespread |
| Squirrel | Small | Native | Mammal | Rodenta and related | Herbivore | Forest |
| Stag | Big | Native | Mammal | Cervidae | Herbivore | Forest |
| Swallow | Small | Native | Bird | Flying bird | Carnivore | Widespread |
| Tapir | Small | Foreign | Mammal | Pachyderm | Herbivore | African/jungle |
| Tiger | Big | Foreign | Mammal | Feline | Carnivore | African/jungle |
| Tuna | Big | Native | Fish | Salt fish | Carnivore | Water |
| Turkey | Small | Native | Bird | Fowl | Omnivore | Farm |
| Turtle | Small | Native | Reptile | Turtles | Omnivore | Widespread |
| Walrus | Big | Native | Mammal | Sea mammals | Carnivore | Water |
| Whale | Big | Native | Mammal | Cetacea | Carnivore | Water |
| Wolf | Small | Native | Mammal | Canine | Carnivore | Forest |
| Wren | Small | Native | Bird | Flying bird | Carnivore | Widespread |
| Yak | Small | Native | Mammal | Bovine | Herbivore | Farm |
| Zebra | Big | Foreign | Mammal | Equine | Herbivore | African/jungle |

Received February 29, 1996
Revision received January 29, 1997
Accepted January 30, 1997 ■