

UC Irvine

UC Irvine Previously Published Works

Title

Impaired ranking of semantic attributes in dementia

Permalink

<https://escholarship.org/uc/item/9gc4718f>

Journal

Brain and Language, 26(2)

ISSN

0093-934X

Authors

Grober, Ellen
Buschke, Herman
Kawas, Claudia
et al.

Publication Date

1985-11-01

DOI

10.1016/0093-934x(85)90043-4

Copyright Information

This work is made available under the terms of a Creative Commons Attribution License, available at

<https://creativecommons.org/licenses/by/4.0/>

Peer reviewed

Impaired Ranking of Semantic Attributes in Dementia

ELLEN GROBER, HERMAN BUSCHKE, CLAUDIA KAWAS, AND PAULA FULD

Albert Einstein College of Medicine

The present work explored the loss of semantic attributes that is said to occur in dementia. In the first two experiments, subjects had to select attributes that went with concepts like *airplane* and *church*. The finding that demented subjects maintained high levels of accuracy when selecting attributes suggested that the semantic content of their concepts was relatively well preserved. The organization of the content was explored in a third experiment by having subjects order attributes according to their relative importance in defining concepts. While demented subjects performed better than chance, they did not rank attributes as well as healthy aged subjects, suggesting a disruption in organization whereby the importance of central attributes is reduced. The hypothesized disruption in organization is viewed in relation to the learning and memory deficit that is the hallmark of the dementias. © 1985 Academic Press, Inc.

The present study explored further the nature of the breakdown in word meanings that has been reported to occur in dementia (Warrington, 1975; Schwartz, Marin, & Saffron, 1979; Fedio & Martin, 1983). The main source of evidence for the apparent breakdown of word meanings comes from tests of naming and identification. The misnamings of demented subjects are commonly names of other items from the same semantic category, for example, *cow* for *horse*, *skirt* for *dress* (Bayles & Tomoeda, 1983; Martin & Fedio, 1983; Schwartz et al., 1979). Similarly, their misidentifications usually involve the selection of another item from the same category (Schwartz et al., 1979). Such errors in naming and identification have been interpreted as indicating the loss of attributes which serve to distinguish related concepts from one another. More direct evidence for breakdown in word meanings was reported by Warrington (1975). Demented subjects were near chance in deciding questions concerning the relative size and weight of concepts (e.g., *bigger than a*

This research was supported by Teaching Nursing Home Award AG03949, NS-19234, NS-03356, HD-01799, and AG04623. We thank Ellen Brown for help in preparing the manuscript. Address correspondence and reprint requests to Dr. Ellen Grober, The Saul Korey Department of Neurology, VE 319, Albert Einstein College of Medicine, 1300 Morris Park Avenue, Bronx, NY 10461.

breadbox; heavier than a telephone book) and were only somewhat better on questions involving discrete attributes (e.g., *made of metal; found outdoors*).

The first two experiments evaluated the extent to which there is an erosion in the content of semantic information associated with a concept. A third experiment evaluated the extent to which there is a disruption in the organization of that information.

EXPERIMENT 1

The first experiment assessed the extent to which attributes have been eroded from the representation of concepts like *airplane* and *car*. The term "attribute" is used here to refer to the individual pieces of information in a concept's representation. It was assumed that the content of a representation could be captured by the set of words that intact speakers associate with the concept. As an illustration, the representation of *airplane* came to include the attributes of *fly, fast, runway, pilot, passenger, radar,* and *travel*, among others. If dementia is associated with an erosion of attributes, then demented subjects should fail to include semantically appropriate information in their representation of a concept's meaning. This prediction was tested by a checklist procedure in which subjects are asked to think about the meaning of concepts like *airplane* and then decide, for a list of words that follow, which words are important to understanding the concept. Some of the words are related to the concept (e.g., *pilot, passenger, sky*) and some are not (e.g., *cake, grass, romance*). The hypothesis that there is an erosion of attributes in dementia would mean that demented subjects should respond to fewer related words than nondemented subjects, that is, they should have a significantly lower hit rate.

Methods

Stimulus materials. A list of words which described attributes of 12 high-frequency nouns were elicited from a group of six students and faculty in the Neurology Department at the Albert Einstein College of Medicine. A comparable group of seven informants rated each resulting attribute according to whether it was considered an essential part of the meaning of the test noun, a nonessential or accidental part of its meaning, or an attribute of intermediate importance.

Attributes that were considered essential or of intermediate importance by a majority of the informants comprised the targets. Nontargets or foils consisted of attributes from other test nouns that were randomly assigned to checklists with the constraint that there be no obvious semantic relationship between the test noun and the foil.

A checklist consisted of nine targets and nine foils randomly arranged in a single column below the test noun. An example is given in Table 1. Ten checklists were constructed and administered to six normal elderly subjects. The five checklists on which they displayed errorless performance were used in the present study. The first checklist was considered practice.

Procedure. Subjects were informed that this was a study about words and their meanings. They were instructed to think about the meaning of the test item and then to go through

TABLE 1
CHECKLIST FOR THE CONCEPT *Airplane*

Airplane	
Wood	Reptile
Fly	Pilot
Cake	Passenger
Radar	Travel
Heirs	Grass
Romance	Breakfast
Fast	Airport
Runway	Conversation
Sky	Hands

the words beneath it and check off the words which were related to the item. They were further instructed that only those words which were important to understanding the test item should be checked off. Nondemented subjects completed the checklists at their own pace. The experimenter (E.G.) helped the demented subjects by reading each word aloud and asking them whether or not it was related to the item under study.

Subjects. All subjects were participants in ongoing research programs at Albert Einstein College of Medicine (AECOM). Tables 2 and 3 contain general information on the subjects in the demented and nondemented groups, respectively, that participated in the various experiments. The demented group consisted of 17 females and 3 males and the nondemented group consisted of 12 females and 7 males. There was no difference in mean age between demented and nondemented subjects (79.4 vs. 80.2 years, respectively; $t = .33, p > .05$) or in mean years of education (12.7 vs. 11.9 years, respectively; $t = .69, p > .05$). While the mean score of the demented subjects on the Wechsler Adult Intelligence Scale (WAIS) vocabulary subtest was average for their age, it was significantly lower than the mean score of the nondemented subjects (10.4 vs 12.2, respectively; $t = 2.04, p < .05$). Nondemented subjects had scores on the Blessed Mental Status Test (Blessed, Tomlinson, & Roth, 1968) that ranged from 0 to 8. A score on the Blessed reflects the number of errors made on questions involving orientation, concentration, memory, and general information. A score of 8 or less is thought to reflect normal mental status in persons of this age (Fuld, 1978). Demented subjects had scores that ranged from 9 to 30.

Evaluation of the demented subjects included history, physical and neurological exam, chemical screen and blood count, thyroid functions, serum vitamin B12 and folate levels, and serological test for syphilis. A computerized tomographic scan (CT) and electroencephalogram (EEG) were performed in most cases. No patient had a history of psychosis, alcoholism, or evidence of severe depression or Parkinson's disease.

A "mixed" dementia group was used because there was no a priori reason to expect that semantic deficits of the sort being tested would be restricted to a particular etiology. Twelve of the 20 patients met criteria for probable Alzheimer's disease (AD) (Eisdorfer & Cohen, 1980; American Psychiatric Association, 1980) and 3 were diagnosed as having multi-infarct dementia (MID) according to published research criteria (Hachinski et al., 1975; American Psychiatric Association, 1980). The Hachinski ischemic score, a systematic method for assigning a value to the clinical features associated with stroke, was used along with other data (e.g., laboratory and neuroradiographic findings) to differentiate patients with AD from those with MID or mixed dementia (MIX). All patients with diagnosis of MID had a modified Hachinski score of 4 or more (Rosen, Terry, Fuld, Katzman, & Peck, 1980). Three of the 20 patients did not meet standard criteria for either AD or MID and

TABLE 2
GENERAL INFORMATION ON DEMENTED SUBJECTS

Subject ID	Sex	Age	Years of education	Score on Blessed mental status test	WAIS vocabulary age scaled scores	Diagnosis
1	F	90	12	23	11	NPH
2	F	77	8	25	6	AD
3	F	63	14	11	10	AD
4	F	90	14	16	15	AD
5	F	87	12	19	11	AD
6	F	79	16	18	13	AD
7	F	85	12	19	10	MID
8	F	83	12	14	14	MID
9	F	81	—	16	12	Unknown
10	F	68	16	16	3	Unknown
11	F	60	12	12	7	AD
12	M	80	20	11	15	AD
13	F	62	16	13	9	AD
14	F	80	12	18	11	MID
15	F	84	12	30	11	AD
16	F	87	8	14	10	AD
17	M	90	6	21	8	AD
18	M	73	20	23	—	AD
19	F	80	8	9	9	NPH
20	F	88	12	11	12	Unknown
	\bar{X}	79.4	12.7	17.0	10.4	
	<i>SD</i>	9.5	3.8	5.4	3.0	

were described as having a dementia of unknown etiology. The remaining two patients were thought to have normal pressure hydrocephalus based on a clinical triad of dementia, a severe gait disturbance, and incontinence accompanied by prominent ventriculomegaly on CT scan with minimal sulcal atrophy. The first 14 entries in Table 2 and the first 11 entries in Table 3 comprised the demented and nondemented subjects, respectively, who participated in Experiment 1.

Results and Discussion

The first column of Table 4 presents the proportion of target words that were selected by the demented and nondemented groups (i.e., hit rate). The second column presents the proportion of foils that were selected by each group (i.e., false-alarm rate).

Although demented subjects responded correctly to 95% of the targets, their hit rate was still significantly lower than that of nondemented subjects ($t = 2.805$, $p < .05$). They missed a total of 22 targets of 504. The availability of ratings from intact speakers on the importance of targets to test nouns allowed the determination of whether or not there was a pattern to the missed targets. Targets that were considered an essential

TABLE 3
GENERAL INFORMATION ON NONDEMENTED SUBJECTS

Subject ID	Sex	Age	Years of education	Score on Blessed	WAIS vocabulary age scaled scores
1	F	93	11	4	13
2	F	77	14	0	15
3	M	77	8	3	11
4	F	79	12	0	13
5	F	79	14	1	15
6	M	79	18	7	12
7	M	83	12	8	12
8	F	73	13	6	12
9	M	76	8	3	9
10	F	81	20	0	17
11	F	87	14	2	13
12	F	77	14	3	14
13	M	79	8	5	12
14	M	81	4	7	6
15	F	77	8	3	10
16	F	85	12	3	15
17	M	66	12	0	10
18	F	82	12	3	12
19	F	93	12	4	11
	\bar{X}	80.2	11.9	3.3	12.2
	<i>SD</i>	6.4	3.7	2.5	2.5

part of the meaning of test nouns were missed as frequently as targets that were considered of intermediate importance ($\chi^2 = 3.68, p > .05$).

The relatively modest decrease in hit rate for demented subjects was coupled with a more marked increase in their false alarm rate. This same pattern has been found in recognition memory tasks and serves to distinguish demented subjects from healthy elderly subjects (Branconnier, Cole, Spera, & DeVitt, 1982). Demented subjects responded to significantly more foils than nondemented subjects ($t = 4.023, p < .05$), raising the

TABLE 4
RESULTS OF EXPERIMENT 1

	Hit rate	False-alarm rate	d'	β^a
Demented subjects	.949 (.036)	.126 (.079)	3.344 (0.956)	1.178 (3.842)
Nondemented subjects	.982 (.016)	.028 (.018)	5.221 (0.950)	3.315 (7.531)

Note. Standard deviations are in parentheses.

^a Value is the antilogarithm of $\log(\beta + 1)$.

possibility that their hit rate may be somewhat inflated because of a bias to respond positively regardless of the stimulus. In fact, they did respond positively significantly more often than did nondemented subjects ($t = 2.217, p < .05$).

To separate the effects of response bias and discrimination, a signal detection analysis was performed. The third and fourth columns of Table 4 present mean values for d' , the measure of true sensitivity to targets, and β the criterion used in making judgments. Analyses were performed on the log transformed values of d' and β for each subject. Demented subjects did not discriminate targets from foils as well as nondemented controls ($t = 4.89, p < .05$). While the demented subjects also tended to use a more liberal criterion for their decisions, the difference in criterion setting between the two groups was not significant ($t = .919, p > .05$).

Demented subjects seemed to have difficulty deciding which attributes were important to the understanding of the test noun. For example, after checking off *hands* in the list for *airplane* several subjects said that *hands* were part of the concept of *airplane* because the pilot needed his hands to steer the plane. While the explanation of the connection is indeed correct, the judgment that the connection is important to understand the concept is not.

Thus, two factors have been identified which may be distorting the assessment of semantic representations arrived at in Experiment 1: the first is a bias to respond positively to any stimulus and the second is a problem in judging the importance of the links between words. Experiment 2 was designed to avoid these potential confounds.

EXPERIMENT 2

While demented subjects missed significantly more attributes than did nondemented subjects in Experiment 1, they did respond correctly to 95% of them. The fact that they also responded to significantly more unrelated words than nondemented subjects allows for the possibility that their hit rate might be inflated. To arrive at a more accurate assessment of the extent to which semantic content has been eroded in dementia, we used a forced-choice procedure in which subjects had to choose between one of two words that went with the test noun where one word was a target and the other a foil.

There are at least two ways that subjects can choose between the target and foil in the present study. First, they may be cognizant of some connection between the test noun and the target and pick the target based on this information, or second, failing to find any connection between the test noun and the target, they may pick the foil by guessing. The second account predicts that targets and foils will be selected equally often since, in the absence of any information regarding connections between concepts and test words, the selection of one test word over

the other should be at chance. On the other hand, the overwhelming selection of targets over foils would be difficult to reconcile with the idea that attributes are lost in dementia.

Methods

The first 10 demented subjects from Table 2 participated in Experiment 2. Ten forced-choice lists were constructed from the materials described in Experiment 1 by randomly pairing the nine targets and foils for each test noun. The subject was instructed to think about the meaning of the test noun and then to decide which word from each pair was related to it. The first list was considered practice. There were 72 test pairs in all.

Results and Discussion

Targets were selected overwhelmingly by all of the subjects. Six of the 10 subjects selected all 72 targets. Three of the remaining 4 subjects picked foils once, twice, and four times, respectively. The subject who performed the least well was still correct on 88% of the trials. While the performance of the group tended to be less than perfect ($t = 1.754$, $p = .11$), it was far better than would be expected if specific attributes had been eroded and subjects were merely choosing between the words randomly ($t = 38.11$, $p < .05$).

Although evidence from other studies indicates that attributes may be lost, the consistency with which demented subjects selected targets over foils in Experiments 1 and 2 suggests that by and large attributes were still available at least under the conditions of the present study. Nonetheless, demented subjects did fail to recognize as many targets as nondemented subjects in Experiment 1, a finding we believe may reflect changes in the saliency of specific attributes in a concept's representation rather than the loss of attributes per se.

The explanation we offer is based on the widely held assumption that specific attributes are associated with a concept with certain probabilities or weights rather than in all or none fashion (see Smith & Medin, 1981, for a review of various probabilistic models). These probabilities reflect the saliency of each attribute in the representation and serve to order the content. The term organization as it is used here is meant to reflect only the fact that certain attributes are more important than others to the understanding of a concept.

The results so far may be explained by changes in the probability with which certain attributes are associated with concepts. That is, the relative saliency of attributes may be altered in dementia thereby affecting the organization of semantic information. One possible clue to the nature of such alterations comes from a finding from Experiment 1. Attributes that were considered essential to understanding the meaning of the concept under study were missed as often as attributes that were considered less important. This suggests that the saliency of essential attributes may be reduced in dementia so that these more important attributes are considered

to be no more important than other less essential attributes. Experiment 3 was undertaken to test the possibility that there is a change in the organization of semantic information such that the saliency of essential attributes is reduced.

EXPERIMENT 3

Subjects in this experiment were asked to rank the importance of attributes to the understanding of test nouns. Consider the concept *table* and the related information *furniture*, *wood*, and *department store* corresponding to essential, intermediate, and nonessential aspects of its meaning. If the weights assigned to essential attributes have become reduced, then subjects should make more errors when ranking the information. In particular, the direction of their errors should be to rank essential attributes as being less important than less essential attributes.

Methods

Subjects. There were 18 subjects in the demented group. Information about them is presented in entries 3 through 20 of Table 2. There were 15 subjects in the nondemented group. Information about them is presented in entries 5 through 19 of Table 3.

Stimuli. Three attributes were selected for each of the test nouns described in Experiment 1. The basis of the selection was the ratings they had been given by intact speakers of how important each was to the meaning of the concept (e.g., *airplane*). One of the selected attributes was considered essential (e.g., *fly*), one was considered nonessential (e.g., *luggage*), and a third was considered to be of intermediate importance (e.g., *radar*). Twelve sets of such triples were constructed and then given to a group of 10 new informants to rank order. The nine triples that were ordered in the same expected way by all 10 subjects comprised the stimuli for the present experiment. Thus, there was good agreement between initial ratings of attributes and their rank order.

Procedure. A test noun was presented on a 3 × 5-in. index card and subjects were told to think about its meaning. This was followed by the presentation of three words on separate cards in random order. After the three words were displayed, the subject was told to pick the word that was most important to the concept under study. Once that was done, the word was removed and she/he was told to pick the word of the remaining two that was next in importance to the concept under study.

Results and Discussion

Two analyses were performed. The first was on the proportion of times that subjects rank ordered the triples correctly (i.e., all three attributes in the correct order). Mean proportions for demented and nondemented subjects were .48 ($SD = .26$) and .76 ($SD = .13$), respectively. As predicted by the hypothesis that there is a decrease in weights assigned to specific attributes, demented subjects ordered many fewer triples correctly than did nondemented subjects ($t = 3.82$, $p < .05$). However, they did perform better than would be expected on the basis of guessing alone (.48 vs. .17; $t = 5.17$, $p < .05$).

The second analysis was on the distribution of the most essential attributes as a function of the position they were assigned by demented

and nondemented subjects: either they were considered to be of the greatest importance to the concept under study, of intermediate importance, or of least importance. The distribution for the demented and nondemented groups is given in Table 5.

A χ^2 test indicated that the rankings of the essential attributes by the two groups were significantly different ($X^2 = 22.90, p < .05$). Demented subjects considered essential features to be less important than other features three times more often than nondemented subjects.

GENERAL DISCUSSION

The high levels of accuracy that demented subjects maintained when selecting attributes for concepts are incompatible with the hypothesis that dementia is associated with the loss of specific attributes from semantic representations. The data can be explained if we make two assumptions: first, that each attribute which comprises a word's meaning has a weight that reflects its importance to the understanding of the concept; and second, that dementia causes a reduction in the weights assigned to essential attributes. Thus, the failure of demented subjects to pick targets in Experiment 1 was because the associated weights had been reduced to a level below the cutoff subjects used for making positive responses. The consistency with which targets were picked over foils in Experiment 2 indicates that subjects were cognizant of some connection between the concept and the target. The results of Experiment 3 directly support the hypothesis that there is a reduction in the weights assigned to the most important attributes of at least some concepts. The net effect of this reduction in weights is to change the organization of semantic information from a set of attributes that is ordered by their relative importance to the concept to a set of attributes that is more equally weighted. These results do not appear to be limited to a particular etiology of dementia since as expected the same results were obtained from patients in all of the diagnostic categories included in the sample.

This change in the organization of semantic information may have consequences for verbal learning and memory in demented subjects. We

TABLE 5
DISTRIBUTIONS OF ESSENTIAL FEATURES IN EXPERIMENT 3

	Most important	Intermediate importance	Least important
Demented subjects	.62 (.22)	.29 (.17)	.09 (.08)
Nondemented subjects	.87 (.10)	.11 (.08)	.02 (.05)

Note. Standard deviations are in parentheses.

begin with the assumption that the attributes associated with a concept are ordered according to the weights described above and that these weights determine the likelihood that particular attributes get sampled when the concept is presented for learning. Thus, salient attributes are more likely to be represented in the encoding of a concept than nonessential attributes. Moreover, when the same word is presented again at test (assuming that there is no change in context), there should be considerable overlap in the set of attributes that gets encoded. According to this analysis, the organization of attributes helps to keep encoding variability at a minimum.

A disruption in organization could contribute to an increase in encoding variability in the following manner. The reduction in weights of normally salient attributes could lead to a situation where, in the extreme, all attributes have an equal probability of being represented in the encoding of a concept. Since on each presentation of a concept, only a subset of its attributes gets encoded, and since the selection of attributes is no longer guided by differences in weights, then there should be less overlap in encoded attributes from one presentation to another. This increase in encoding variability could contribute to the depressed verbal learning and memory characteristic of demented subjects.

Other accounts of the data are possible. For example, the results from Experiment 1 could be explained by a reduction in processing capacity which limits the number of attributes that can be retrieved into working memory and considered simultaneously by demented subjects. The results of Experiment 2 are compatible with this account since when only two attributes had to be considered at once, demented subjects made very few errors. However, it is not obvious how limitations in processing capacity alone could account for the results of Experiment 3. An additional mechanism would have to be invoked, perhaps one where decisions regarding the relationship of one attribute to a test word interferes with a subsequent decision involving another attribute.

One final point concerns the extent to which differences in task difficulty may contribute to the pattern of results. It seems reasonable to assume that Experiment 3 was more difficult than Experiment 1 since nondemented subjects performed less well on it (.75 vs. .96, respectively) (Chapman & Chapman, 1973). Yet, such a difference in task difficulty does not in any obvious way account for the major findings: that demented subjects can maintain high levels of accuracy when selecting attributes for concepts; that they are better than chance at ordering attributes but still worse than nondemented subjects; and that there is a reduction in the importance of central attributes. From these findings, it appears that some concepts retain both attribute and order information while others suffer an erosion of order information.

While we think that the most parsimonious account of the present data

involves changes in the organization of semantic information, such an account does not preclude the loss of semantic information as shown by others. That is, the loss of semantic information may represent an extreme case where the weights assigned to specific attributes have become so reduced that they are at a level below that needed for correct identification. Considered together, the results of the three experiments show that even when demented subjects can identify attributes as being part of a word's meaning, they may not appreciate the relative importance of these attributes in delineating the meaning. We have suggested how such a disturbance in organization might affect encoding processes involved in verbal learning and memory. Using similar reasoning, it is not hard to imagine that such a disturbance in semantic knowledge could have profound effects on any cognitive process into which this knowledge enters.

REFERENCES

- American Psychiatric Association (1980). *Diagnostic and statistical manual of mental disorders*. Washington, DC: American Psychiatric Association. 3rd Ed.
- Bayles, K. A., & Tomoeda, C. K. (1983). Confrontation naming impairment in dementia. *Brain and Language*, *19*, 98–114.
- Blessed, G., Tomlinson, B. E., & Roth, M. (1968). The Association between quantitative measures of dementia and of senile changes in the cerebral gray matter of elderly subjects. *British Journal of Psychiatry*, *114*, 797–811.
- Branconnier, R. J., Cole, J. O., Spera, K. F., & DeVitt, D. R. (1982). Recall and recognition as diagnostic indices of malignant memory loss in senile dementia: A Bayesian analysis. *Experimental Aging Research*, *8*, 189–193.
- Chapman, J., & Chapman, J. P. (1973). Problems in the measurement of cognitive deficit. *Psychological Bulletin*, *79*, 380–385.
- Eisdorfer, C., & Cohen, D. (1980). Diagnostic criteria for primary neuronal degeneration of the Alzheimer type. *Journal of Family Practice*, *11*, 553–557.
- Fuld, P. A. (1978). Psychological testing in the differential diagnosis of the dementias. In R. Katzman, R. D. Terry, & K. L. Bick (Eds.), *Alzheimer's disease: Senile dementia & related disorders*. New York: Raven Press.
- Hachinski, V. C., Iliff, L. D., Zilka E., duBoulay, G. H., McAllister, V. C., Marshall, T., Russell, R. W. R., & Symon, L. (1975). Cerebral blood flow in dementia. *Archives of Neurology*, *32*, 632–637.
- Martin, A., & Fedio, P. (1983). Word production and comprehension in Alzheimer's disease. The breakdown of semantic knowledge. *Brain and Language*, *19*, 124–141.
- Rosen, W. G., Terry, R., Fuld, P., Katzman R., & Peck, A. (1980). Pathological verification of ischemic score in differentiation of dementia. *Annals of Neurology*, *7*(5), 486–488.
- Schwartz, M. F., Marin, O. S. M., & Saffran, E. M. (1979). Dissociation of language function in dementia: A case study. *Brain and Language*, *7*, 277–306.
- Smith, E. E., & Medin, D. L. (1981). *Categories and concepts*. Cambridge: Harvard Univ. Press.
- Warrington, E. K. (1975). The selective impairment of semantic memory. *Quarterly Journal of Experimental Psychology*, *27*, 635–657.