Application of Signal Detection Theory to Prose Recall and Recognition in Elderly and Young Adults[1]

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Immediate and delayed (one-week) recall and recognition of connected verbal material in a group of 44 elderly and young adults were investigated. Recognition performance was assessed with Signal Detection Theory techniques, in order to analyze retention independently of response criterion. The relationships between performance and sex, education, occupation, and WAIS Vocabulary Score were also studied. The aged showed a relatively greater decrement in long-term recall than immediate, and lower recognition memory scores at both intervals. There were no age differences in response criterion. Of the background variables, WAIS Vocabulary had a positive relationship to performance, and occupation was negatively related to memory scores. The results provided evidence for a storage deficit in the elderly, at least with prose material.

THE retention of connected discourse is an area of research which received little attention for many years following Bartlett's (1932) early work. The study of processes involved in prose memory can yield much information regarding how adults organize information under ordinary, "everyday," as opposed to laboratory, conditions (Deese, 1961; Dooling & Lachman, 1971; Pompi & Lachman, 1967; Sasson, 1971). With respect to studies of old age, Hulicka (1967) has suggested that the use of meaningful verbal material is particularly useful because it serves to maintain the motivational level of older persons to a greater extent than would lists of words or nonsense syllables. Moreover, it makes it easier to determine the degree to which a memory deficit in old age observed in the laboratory extends to situations encountered in the course of daily activities.

In the present study, recall and recognition memory for prose was measured. A number of studies (Crenshaw, 1969; Harwood & Naylor, 1969; Schonfield & Robertson, 1966) have made this comparison as a means of distinguishing between storage and retrieval deficits in the aged. For subjects of all ages, recognition performance is superior to that of recall. When comparing younger and old adults, however, the older subjects perform disproportionately poorer on recall than do the young. Schonfield and Robertson (1966) found that elderly and young adults did not differ in recognition scores, but the elderly had significantly poorer recall. Since recall is assumed to depend upon retrieval processes and recognition does not, the conclusion has been that the elderly have deficient retrieval processes. This interpretation has been criticized because it does not take into consideration the fact that recognition and recall tasks also differ in their dependence on storage processes. McNulty and Caird (1966) and Tulving (1968) have pointed out that less information about an item needs to be stored in order to be able to recognize rather than to recall it. It is pos-

sible that the elderly do not store as much information as younger subjects and that retrieval is not as greatly affected by aging. McNulty and Caird (1966) predicted that if the storage hypothesis is correct, there should be instances in which the elderly's performance on recognition and recall would be equally deficient with respect to that of younger subjects. Several studies have found such a relationship to exist under certain conditions (Caird, 1965; Gordon & Clark, 1973; Harwood & Naylor, 1969). The results of the present study should provide further data regarding the storage versus retrieval issue.

In the analysis of recognition performance, the use of measures derived from Signal Detection Theory (SDT) have proved to be of value (Green & Swets, 1966). In the present study, SDT measures for recognition memory developed for use with nonsense or word material have been adapted for use with prose. The technique allows for the separation of the ability of the subject to discriminate between old and new stimuli (d'), which depends upon retention, from the response criterion, which depends upon the subject's response biases, i.e., his tendency to respond "old" to both old and new stimuli. As illustrated below, d' and L_x scores reflect the effects of both the proportion of "old" responses to old stimuli (probability of a hit) to the proportion of "old" responses to new stimuli (probability of a false affirmative).

	Hit Rate	False Affirmative Rate	d'	Lx
(1)	.66	.12	1.58	1.83
	.88	.34	1.58	.55
(2)	.66	.12	1.58	1.83
	.66	.22	1.18	1.24

Depending upon the ratio of hits to false affirmatives it is possible to obtain the same value for d' from two different hit rates as in (1). Based upon hit rate alone, one would conclude that the subject with the lower score has a poorer memory. However, this subject also has a lower false affirmative rate. It can be seen that these two subjects actually demonstrated similar retention. The subject with the lower false affirmative rate was more cautious about responding "old" to both old and new stimuli, and therefore had a higher response criterion, or Lx. Conversely (2) shows that two individuals may have the same hit rate

but have two different d' scores, depending upon the false affirmative rate. Again, based upon hit scores alone, it would be concluded that these subjects had exhibited equivalent retention. In actuality, the one with the higher false affirmative rate had been guessing more, and this inflated his hit rate. When the effects of guessing are taken into account, as with SDT measures, a more accurate estimate of memory is obtained.

In the present experiment, age differences in d' and L_x were expected, but the direction of the differences could not be predicted. If it is assumed that the elderly are more cautious than younger adults in emitting responses, but have similar discriminability (Botwinick, 1966; Silverman, 1963) it would be expected that the elderly would set higher response criteria and have similar d's as younger persons. This relationship has been reported by Rees and Botwinick (1971) in an auditory perceptual task and by Craik (1969) on recognition memory performance. In contrast, if elderly persons are more anxious, it may be expected that they will have lower L_x's and d's than younger subjects. Ganung (1972), Gordon (1973), and Ross (1968) have found that the elderly perceive as anxiety-provoking situations in which their cognitive abilities are being evaluated. Clark and Greenberg (1971), using young adult subjects, found that both d' and L_x decreased between trials under a condition of instruction-induced stress. Thus, it was considered possible that caution and anxiety could differentially affect age differences in d' and L_x.

The sample of older persons consisted of members of the Institute for Retired Professionals at the New School for Social Research in New York City.[4] These persons were taking part in educational activities at the college level and as a group were functioning far above the level of community elderly. Many studies of the aged have placed the older subjects at a disadvantage in comparisons of cognitive performance with younger persons. In these studies, institutional residents or members of senior centers have been compared to college students. In the present experiment, a more reasonable basis for age comparisons exists.

In order to provide an assessment of the contributions of variables other than age affecting memory performance, multiple regression techniques were used to assess the independent contributions of differences in sex, verbal intelligence, years of education, and occupational levels.

METHOD

Subjects

The sample consisted of 44 persons, one-half elderly and the others young adults. There were 10 males and 12 females in each group. Table 1 presents the means and standard deviations for both groups on age, score on the Vocabulary Scale of the Wechsler Adult Intelligence Scale (WAIS), years of education, and level of occupation. The elderly subjects ranged in age from 65-81 years, and the young adults, from 21 to 30 years. The highest score possible on the WAIS was 80. Occupational levels were defined according to the classification of occupations in the 1970 US Bureau of the Census: (1) Long-term unemployed; (2) laborer; (3) service worker; (4) operatives and kindred workers; (5) craftsmen, foremen, etc.; (6) salesworkers; (7) clerical workers; (8) managers, officials, proprietors; (9) professional and technical workers.

As can be seen from Table 1, there was the least variation in occupational level for the elderly males, more for the females, and

Table 1. Means and Standard Deviations of Sample Characteristics by Age and Sex.

| | Old | | Young | |
	Male	Female	Male	Female
Age				
X̄	71.30	71.17	25.10	24.42
S.D.	5.06	5.00	2.73	2.43
WAIS vocabulary				
X̄	72.20	73.67	74.20	74.17
S.D.	7.41	5.53	3.85	1.80
Years of education				
X̄	15.90	17.33	16.60	16.67
S.D.	3.87	.98	.97	.98
Occupation				
X̄				
S.D.	8.60	8.17	5.70	8.33
	.97	2.33	3.20	1.15

the most for the young males. These differences in variance reflected the fact that most of the elderly were in the upper two levels of the scale, while the young subjects, particularly the males, fell into all levels except that of service worker.

The sample of older persons, as was mentioned above, consisted of members of the Institute for Retired Professionals in New York City. The sample of young adults was composed of graduate students at Columbia Univ. and Teachers College, Columbia Univ., New York City.

Procedure

The subjects were tested individually for free verbal recall, and recognition of a paragraph of connected discourse. Instructions to each S for recall were as follows:

I am going to give you a sheet of paper which has a paragraph written on it. I would like you to read this paragraph out loud. It is not necessary for you to read it quickly; just read it at your own normal reading pace. While you are reading it, try to follow the chain of events that is described, because as soon as you finish it, I am going to ask you to tell me as much as you can about what is contained in the paragraph.

The subject was then given instructions for recognition and was given examples of the nature of the questions that would be asked about the paragraph. The subject then read and recalled the paragraph and was then given the recognition questions. Following the recognition test, the vocabulary scale of the WAIS was administered and demographic data collected. The subject was asked to return 1 week later for further testing. No indication of the nature of the second testing was given in order to avoid rehearsal of the material by the subject.

Delayed recall for the paragraph and delayed recognition memory were tested at the second session, with the same recognition questions that had been used in the first session in a different random order.

MATERIALS

Recall.—The paragraph presented to each subject was based upon the plan of a story used by Dawes (1966). This material was particularly amenable to the construction of

recognition questions that could be analyzed by SDT measures. The original story was modified to describe the activity of community groups involved in a decision over a public institution in a large city. It was felt that this subject matter would be more meaningful to the subjects in the present sample than that used by Dawes. By changing the content, it was also possible to create a variety of situations so that 15 different stories could be administered to all the subjects. It was considered necessary to do this, so that the subjects would not communicate among themselves as to the nature of the material. All the stories were constructed so that they were equivalent in logical structure. Following Dawes, each story consisted of a description of 10 logical set relationships between 5 groups of persons. An example of one of the stories is presented in the appendix. As can be seen from this example, the "establishment" group lost the issue. In approximately half of the stories, the "establishment" lost, and in the others, this group won.[5]

Recognition.—A set of 32 true-false questions composed for each of the 15 stories served as the test for immediate and delayed recognition memory for prose. Half of the questions could be answered based upon direct retention of the paragraph, and the other 16 were based upon inferences which could be drawn from the facts presented. Eight statements relating to the paragraph appeared four times in the question booklet. Each time a statement appeared, it was preceded with the word "no," "few," "many," or "all." The order in which the statements appeared was completely random. Ss were asked to respond "true" or "false" to each statement separately. Only one such statement out of every four was actually true, and the others were false, according to the facts presented in the story. The nature of these statements is demonstrated by the following examples, which are based upon the passage in the Appendix:

    (1) No members of the pro-science association are professors.
    (2) Few members of the pro-science association are professors.
    (3) Many members of the pro-science association are professors.
    (4) All members of the pro-science association are professors.

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[5] The prose materials and true-false questions will be made available from the senior author upon request.

Only (3) would be considered to be true. It had been clearly specified to each subject prior to reading the paragraph, that only one statement out of the four could be true.

MEASURES

Recall.—A simple content analysis was conducted to analyze recent and delayed recall of the paragraph from the tape recordings of each subject's recall. The experimenters divided the story into parts which were considered to represent units of conceptual information. The nature of the material was such that it was fairly easily separated and scored by discrete units. One point was scored for each correct item in the subject's recall if the general meaning of the unit was conveyed. The maximum score that could be obtained was 18. It was not possible to have another rater score each of the 88 protocols and thus obtain a reliability coefficient. However, collaboration with an independent judge on a random sample of recalled material indicated that the method of scoring was not overly subjective.

Recognition.—The true-false questions were designed so that they could be analyzed with SDT measures. In order to apply this type of material to the recognition paradigm, "true" and "false" were considered to represent "old" and "new," respectively. It was then possible to compute values of d' and Lx from the proportion of true responses to true statements (hits) compared to the proposition of "true" responses to false statements (false affirmatives).

RESULTS

The means and standard deviations for scores of elderly and young adults on prose recall and recognition for immediate and delayed retention intervals are presented in Table 2.

For recall, and factual and deductive recognition, separate stepwise multiple linear regressions were carried out. In all three analyses, age, sex, trial (immediate or delayed), WAIS score, years of education, occupation, and age X trials interaction were the independent variables. The age X trials variable was composed of each subject's age multiplied by the number of the trial. This method, which is described by Cohen (1968), was used because it was suspected that the age X trials inter-

action might be a significant contributor to the variance.

The correlation matrix of the independent variables is displayed in Table 3. From this matrix, it can be seen that age had a moderately high positive relationship to occupation and was slightly less strongly related to WAIS vocabulary score. WAIS and occupation had a fairly strong positive relationship, as did WAIS and education. Sex was slightly negatively related to both occupation and education.

Table 2. Means and Standard Deviations of Memory Scores by Age and Retention Interval.

	Retention Interval						
Variable	Immediate				Delayed		
Recall	$\overline{X}$		S.D.		$\overline{X}$		S.D.
Old	9.32		3.58		4.36		3.72
Young	12.18		3.42		10.68		2.36
Recognition d'	Factual		Deductive		Factual		Deductive	
	$\overline{X}$	S.D.	$\overline{X}$	S.D.	$\overline{X}$	S.D.	$\overline{X}$	S.D.
Old	.92	.85	.90	1.02	.86	1.06	1.04	1.19
Young	1.66	1.05	1.51	.90	1.68	1.08	1.63	1.07
Recognition Lx	Factual		Deductive		Factual		Deductive	
	$\overline{X}$	S.D.	$\overline{X}$	S.D.	$\overline{X}$	S.D.	$\overline{X}$	S.D.
Old	1.29	.53	1.25	.70	1.83	1.95	1.57	1.67
Young	2.58	2.34	2.27	2.08	2.13	1.94	1.92	2.00

Table 3. Correlation Matrix of Independent Variables Used in Regression Analyses.

	Variable				
Variable	Age	WAIS Vocabulary	Sex	Occupation	Education
Age	1.00	.11	.02	.34	.14
WAIS vocabulary	.11	1.00	.04	.40	.59
Sex	.02	.04	1.00	-.17	-.06
Occupation	.34	.40	-.17	1.00	.24
Education	.14	.59	-.06	.24	1.00

Note: Males = 1, Females = 0.

Table 4. Stepwise Multiple Linear Regression of Prose Recall by Age, Sex, WAIS Score, Education, and Occupation.

Variable	Increment to R^2	b	F	df
Age X Trial	.347	-.48	45.60**	1,86
WAIS vocabulary	.035	+.23	4.77**	2,85
Occupation	.034	-.17	4.85**	3,84
Sex	.006	+.10	.87	4,83
Age	.006	-.14	.90	5,82
Years of education	.001	+.04	.15	6,81
Constant		6.47		

*$p<.05$
**$p<.01$

The results of the stepwise multiple linear regression analysis of prose recall are presented in Table 4. The variables are listed according to the order in which they were entered into the regression equation. F-tests for significance were carried out on the ratio of the regression mean square divided by the residual mean square as each variable was entered into the equation. These F-tests indicated that Age X Trials, WAIS Vocabulary, and occupation were significant contributors to the variance explained by the equation (R^2). The beta weights showed that vocabulary, sex, and education were positively related to performance, while age, occupation, and Age X Trials had negative relationships to recall. The multiple regression coefficient obtained was equal to .66 which was highly significant (F = 0.12, df=6, 81, $p < .001$).

From the regression analysis along with the means presented in Table 2, it appears that the elderly performed somewhat more poorly than the young adults on immediate retention, but had much lower scores on delayed recall. In addition, WAIS Vocabulary was positively related to recall performance on both trials, while occupation had a negative relationship to recall.

For factual and deductive prose recognition, d' and L_x scores were analyzed in a similar manner as prose recall. Table 5 displays the order in which the variables were entered into the equations for factual and deductive recognition d'. The F-tests showed that for d' on both types of recognition questions, age and occupation were significant contributors to the variance. From the beta weights, it can be seen that both age and occupation were negatively related to both types of recognition memory, while WAIS Vocabulary was positively related to factual recognition d'. The regression coefficients for factual and deductive d' were, respectively, .50 (F=3.81, df=7,80, $p < .001$) and .40 (F=2.58, df=6,81, $p < .025$).

The regression coefficients for factual and deductive L_x, when tested by F-tests, were not significant. The coefficient for factual L_x was .29 (F=1.27, df=6,81) and for deductive was .30 (F=1.36, df=6,81). Since the over-all amount of variance explained by the independent variables was not very great, the orders in which the variables were entered into the equation are not being considered.

DISCUSSION

The results of the regression analyses indicated that age, WAIS Vocabulary score, occupation, and retention interval were all related

Table 5. Stepwise Multiple Linear Regression of Factual and Deductive Recognition d' by Age, Sex, WAIS Score, Education, and Occupation.

Variable	Increment to R^2	b	F	df
Factual d':				
Age	.135	−.34	13.45**	1,86
Occupation	.055	−.35	5.73**	2,85
WAIS vocabulary	.056	+.25	6.23**	3,84
Age X Trial	.003	+.05	.30	4,83
Sex	.001	+.04	.11	5,82
Education	.000	+.03	.03	6,81
Trials	.000	+.03	.02	7,80
Constant		.87		
Deductive d':				
Age	.103	−.27	9.92**	1,86
Occupation	.047	−.24	4.69**	2,85
Education	.86	−.09	.58	3,84
Trials	.004	+.06	.34	4,83
WAIS vocabulary	.000	+.03	.04	5,82
Sex	.000	−.02	.028	6,81
Constant		2.95		

*$p<.05$
**$p<.01$

to prose memory scores. Occupation was found to be negatively related to recall and both types of recognition memory d'. It is possible that the poorer memory scores of the higher occupational levels reflected the slight positive correlation between age and occupation. Moreover, there was less variation among the older group in occupational level, since most had been professionals. Had both age groups been asked to give their father's occupation, it is likely that a positive relationship between occupational level and memory would have been observed. In contrast, WAIS Vocabulary score was positively related to both recall and factual recognition memory. With increasing verbal intelligence, then, memory scores tend to improve. Neither sex nor educational level was found to be related to memory performance. Thus, evidence has been provided for the importance of considering background characteristics in comparing groups of divergent ages, regardless of how similar they may otherwise appear. In groups that differ more in education, intelligence, and occupational level than the present sample, it might be expected that even stronger relationships would be observed.

The findings from the present study that recognition scores were poorer for the elderly provide further evidence for the existence of storage deficits in the elderly. According to McNulty and Caird, (1966) if the elderly have a storage deficit, there should be situations in which both recognition and recall are negatively affected. Thus, the elderly have greater difficulty storing prose materials. The results on prose recall indicated that long-term recall of prose is much more severely affected by aging than immediate retention.

Factual and deductive recognition questions had been derived from the prose passage and varied to the degree that manipulations of information in storage were required. That is, for deductive recognition, it was necessary to retrieve two facts from the story and infer the right answers from the retained facts. These questions had been designed in order to determine whether age would differentially affect factual and deductive memory. The results of the regression analysis indicated that both types of recognition memory were poorer in the elderly than in the young adults.

The investigation of age differences in the two SDT measures revealed that the elderly had poorer recognition memory for both retention intervals, but had similar response criteria as younger subjects. With prose material, it appears that caution and anxiety operate in different ways than with other verbal materials. It is also possible that the recognition questions themselves were inadequate for discriminating between age groups with respect to response criterion. It was apparent during the course of testing that the elderly found the true-false questions to be somewhat confusing, particularly the distinction between "many" and "all." Such confusion may have led to an increased number of false affirmatives, since the subject would be responding with more "trues" to false statements. The younger subjects understood the task better and at least were less reticent than the older persons in asking for clarification. By the second session, the elderly seemed to better comprehend the structure of the questions, since they increased their L_x scores over the previous trial. This would indicate that they made fewer false affirmative errors. In future investigations with prose material, more thorough instructions would have to be given, and a greater effort made to ascertain that all subjects are aware of the structure of the task before they begin.

The extension of SDT measures to analyzing prose retention has important implications for research on connected verbal material as well as on future studies of aging. It provides for a systematic measure of retention for material which up to the present time has been associated with a high degree of subjectivity. At the same time, it is possible to differentiate between attitudinal bias and actual retention of the information contained in the material. In the present study, it has not been possible to determine whether the elderly differ from younger adults in attitudes toward responding with prose material. It has been shown that the elderly are deficient at retaining the type of information which is required in "everyday," meaningful, verbal experiences.

SUMMARY

Immediate and delayed (1-week) recall and recognition of connected verbal material was measured in a group of 44 men and women. Half of the sample consisted of young adults (mean age=24.76 years) and the others were elderly (mean age=71.23 years). Meas-

ures derived from Signal Detection Theory were used to analyze recognition memory independently of response criterion. Background characteristics of the sample, including sex, education, occupation, and verbal ability, were also investigated. There were age differences in recall at both retention intervals. The difference between the two age groups on delayed recall was greater than that observed for immediate. The elderly also achieved lower recognition memory scores at both retention intervals. There were no significant differences between the age groups on response criterion. The results provided evidence for a storage deficit in the elderly. The failure to differen-

tiate between age groups on response criterion was discussed in terms of differences between aged and young adult subjects in their comprehension of the logical structure of the questions. Of the background variables, verbal ability and occupation were found to have the strongest relationship to performance. The extension of the Signal Detection Theory measures to the analysis of prose recognition in the aged was seen as having potential for future research in the area. It was concluded that the elderly appear to have difficulty in retaining information which is required in "everyday" verbal experiences.

Appendix

One of the Fifteen Paragraphs
Used to Test Recent and Delayed Prose Retention

Library

There is a public library in a large city which is run by a ten-man board of directors. The librarians who work in the library have worked there for many years and know the most about the operation of the library. A large amount of money has been donated to the library. The donor has told the board of directors that the citizens of the surrounding community must be allowed to vote on how the money should be spent. The board of directors, whose members were chosen because they know the most about the library, would like to spend the money to increase their collection of poetry books. A group of citizens from the community, who are professors of science at a nearby university, are interested in having the money spent on scientific books. None of the professors are librarians. Although the plan to use the money is opposed by most of the board members, the science professors persuade a few members of the board of directors to back the plan. These board members, together with many professors, form a pro-science association. The vote on how to use the money is then taken among the people in the community. All the members of the pro-science association and all the science professors voted for using the money for science books, and everyone else voted against it. The majority vote turned out in favor of increasing the number of scientific books in the library. After the new books were bought and put on the shelves, many people from the community were pleased, and used the library more than ever. The board members, though, were disappointed that they had not been able to get more poetry books for the library.

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