INSTITUTE FOR THE
STUDY OF
INTELLECTUAL
BEHAVIOR

The Effects of Different Types of Word Processing on Memory Performance in Young and Elderly Adults

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Program* on Cognitive Factors in Human Learning and Memory Report No. 48

Institute for the Study of Intellectual Behavior

University of Colorado

Boulder, Colorado 80302

December 1975

ABSTRACT

The purpose of this Ph.D. dissertation was the investigation of learning and memory problems in elderly adults, evaluating (A) the effects of different types of word processing and intent to learn on recall and recognition, (B) the existence of retrieval deficits in the old, (C) different kinds of semantic and physical processing tasks in both age groups, and (D) individual differences in a free-responding task. Following digit span and anagram pretests, 80 adults age 60 or over and 80 college students were instructed to respond to each of 30 unrelated nouns with either its category name, an associated word, a rhyme, a letter description, or in any manner they wished (with separate incidental and intentional learning groups for each of these tasks). Then all subjects were given a free recall followed immediately by a cued recall (using the responses given during word processing), and then a yes-no recognition test and anxiety self-report.

The young recalled more words than the older subjects and performed better on the recognition test. Although semantic processing produced superior performance in both groups, the age difference in recall was much larger with the semantic than the physical tasks, while the opposite was true for the recognition measures. Intent to learn facilitated only free recall and did not significantly interact with age or processing. Categoric produced superior free recall to associative processing only in the young, with categoric cueing advantage greater in both age groups. Rhyming was equivalent to orthographic processing in free recall and superior in cued recall, with age deficits reduced or eliminated therein. These and other results are interpreted as demonstrating age deficits to be localized primarily in deeper semantic levels of processing, reflecting insufficient elaboration by the elderly of semantic traces with consequent difficulties in retrievability.

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*Supported by NSF Grant GB34077X

CHAPTER I

INTRODUCTION

A wealth of evidence has been accumulated in recent years regarding variables which affect learning and retention of verbal materials. However, the great majority of these studies have involved college students as subjects. Since old age is a fact of life which most human beings must eventually face, it is both important and practical to investigate verbal behavior in the elderly. This is emphasized by reviewers of the aging literature who have made conclusions such as, "Aged persons do not learn as well as do the young (Eisdorfer, 1968, p. 189)," and "Efficiency declines with age in all processes that are involved in memory function (Talland, 1968, p. 94)." While it's true that comparisons of verbal learning in college-age students and older adults have tended to favor the younger subjects, it seems more important to discover the components of this deficit in order to find strategies of learning and memory which may help the elderly to overcome their problems. A brief review of previous studies will indicate the nature of these problems and provide direction for the experiment described in this paper.

Coding

While memory decline with age is a well documented fact, the decline is primarily associated with material which exceeds the memory span. For example, several investigators (i.e. Talland, 1968; Drachman & Leavitt, 1972) have shown that young and old subjects do not differ in tests of the forward digit span. However, if asked to free recall a number of letters or digits exceeding the span, young subjects will perform better, increasingly so the longer the list (Taub, 1968b).

Craik (1968) has suggested that older subjects are less able to handle supraspan material because they suffer from a coding deficit. In a study on recall of passages varying in approximations to English, he found that older subjects benefitted less than the younger ones from the higher approximations. In another experiment which involved a memory span technique, the old did not differ from the young in the recall of color names, but their recall was worse than the young when the materials were sentences or scrambled proverbs and presumably required more chunking by the subjects. Talland (1968) reported that subjects over age 60 derived less advantage from grouping nine-digit numbers in triplets for purposes of serial recall than did younger subjects. This result was recently confirmed by Taub (1974) in an experiment on the serial recall of letters. For sequences which could not be recoded into words, the old did not differ from the young, but for the codable sequences, the older subjects' performance was worse. These studies demonstrate that the locus of learning and memory problems in the aged is primarily in verbal material which exceeds the memory span, and this is related to a decreased ability by the old to recode the materials in a form which is more amenable to memorization.

Storage and Retrieval

An issue which has received much attention in geriatric research is whether age decrements in learning and memory are due primarily to problems of storage, retrieval, or both. To date, the majority of the evidence has favored a retrieval interpretation. Two paradigms have been the main vehicles for this research: recognition tests and cueing procedures.

It has been theorized that recall tests of memory performance involve both storage and retrieval processes, whereas recognition tests bypass the retrieval stage of memory (Kintsch, 1970). Thus, Schonfield and Robertson (1966) in a within-subjects comparison found that young subjects recalled a 24-word list better than older subjects, but there were no age-related differences in recognition. This result has been attributed to a retrieval deficit in the elderly. Others have demonstrated age differences in both recall and recognition, but with these being less in magnitude for recognition (Harwood &

Naylor, 1969).

Using separate groups of young, middle-aged, and old subjects, Craik (1971) reported data for a "short-term" recognition experiment as well as a "long-term" recognition test. With the former task, the subjects were presented seven two-digit numbers and had to decide later whether a test pair had occurred in the series. The "long-term" task involved the presentation of 25 common words and the subsequent yes-no recognition of these when they were shown with 25 distractors. The notable feature of Craik's investigation was the use of confidence ratings and signal detection analyses which allowed the measurement of recognition memory separate from the influence of response criterion factors. Recognition performance, as measured by d', did not significantly differ among the three age groups in either task, although there were nonsignificant differences favoring the young with the "long-term" test. In addition, rate of forgetting with the probe procedure, as measured by the influence of serial input position, did not vary with age. Craik concluded that "the major source of difficulty which older subjects encounter is located at retrieval (p. 322)."

This statement was challenged in a study by Gordon and Clark (1974). They found no age differences in d' in recognition of 20 old and 20 new items on the first recognition test trial. However, the young were significantly better than the old after a second study and test trial, due to the older group's failure to retain items they had previously gotten correct. The results were interpreted as evidence for increasing decay of stored memory traces with increasing age. However, another possibility is that the distractors on the first recognition test trial caused more confusion and interference for the old than the young. This notion is supported by studies of dichotic stimulation where the subjects are presented two sets of materials simultaneously, one set to each ear. When they are asked to recall the materials for each channel separately, there is no age difference in the first half of the report, but the old are worse than the young on the second half (Inglis & Caird, 1963). Taub (1968a) demonstrated a similar effect using single channel presentation and differentially colored letters for materials. With a different paradigm, Talland (1968) found an age decrement when the subjects were required to report the number not repeated in a second presentation of digits. These experiments have been interpreted by Craik (1971) as showing that tasks which require attention to be divided between two processes are a common source of difficulty for the aged. Thus, it is possible that on a second recognition study trial, the older subjects experience difficulty in simultaneously processing targets previously recognized, "new" targets or misses, and distractors from the first test trial.

If older subjects do have retrieval problems, as the above studies suggest, then providing a strategy to aid retrieval, such as retrieval cueing, should aid recall in older subjects relatively more so than in their younger counterparts. Numerous studies of college students have supported Tulving and Pearlstone's (1966) notion that providing appropriate cues can aid the recall of words which are available but not accessible. Studies of cueing processes in older people are few and are plagued with methodological problems. Using a between-subjects design, Laurence (1967) found that taxonomic category cues aided older subjects relatively more so than younger subjects. Thus, in the uncued condition, the old were significantly worse in recall than the young, but with cued recall, the difference was not significant. However, the absence of a significant cueing effect for the young subjects suggests that the 36-item list may have had too few categories (six) and caused a ceiling effect in this group. Drachman and Leavitt (1972) found no differential cueing effect due to age using initial letter cues and a 35-word list. However, their comparison of cued and uncued conditions was between lists learned by each subject under either condition rather than between uncued and cued items from the same list. In addition, the length of their list suggests that some of the letter cues had more than one target word while others did not, a cueing situation which is likely to be confusing as well as inefficient (Earhard, 1967; Lauer, Streby, & Battig, in press).

One recent experiment by Hultsch (1975) has helped to clarify the issue. Separate groups of young, middle-aged, and old subjects learned a 40-item 10-category blocked list for six trials under either taxonomically cued or uncued recall conditions. The young were significantly better than the other two age groups on both free and cued recall. When these data were broken down into number of categories and words per category, the same differences were obtained for the latter measure. However, for categories recalled, age differences were significant only in the uncued condition. Thus, cueing aided the older subjects relatively more so than the young in retrieving higher order units, but did not improve the accessibility of those items within the units, a result which has been found in previous studies of college students (Mondani, Pellegrino, & Battig, 1973; Lauer, 1974). This study suggests that the relative effectiveness of retrieval cues for the old may depend on the number of items per cue as well as the nature of the materials involved.

Several investigators have implied that the old have problems with retrieval because the search task is more complicated for them. Thus, Craik (1968) found increasing age differences in recall as the size of the "vocabulary" of the materials increased from small (digits) to large (animal names). Anders and Fozard (1973) reported longer retrieval latencies and thus slower searches by the old in tests of both short- and long-term memory. It was suggested by Hultsch (1971) that the verbal network of the old may be more complicated than in the young causing an effectively larger search. This idea is supported by the extensive psycholinguistic research of Riegel (1968) which has shown that for the elderly, there is increased variability in word associations and longer associative reaction times. He has claimed that the cumulative vocabulary input of the older person is much larger than the young, and that increased variability reflects decreasing frequencies for individual responses. The notion of a search problem and the results of Hultsch (1975) where the old equaled the young only in category recall suggests why cueing may not always decrease age differences while recognition tests more frequently do so, since in the latter case, generation and search are not required.

Differences in Encoding Processes

One current notion of verbal learning which has received little attention in the aging literature is the levels of processing approach suggested by Craik and Lockhart (1972) but which also has some origins in the incidental-intentional learning literature. The basic notion is that type of processing rather than amount of processing of the material to be learned determines performance differences. Thus, several studies have shown that instructing subjects to attend to or process the semantic features of a list of words produces equivalent performances for incidental and intentional learners. However, if the subjects process orthographic, physical, or acoustic features instead, then intent to learn becomes more important and will produce better recall than in the incidental conditions (Hyde & Jenkins, 1969; Mondani et al., 1973). Other experiments have shown the general superiority of semantic over acoustic and orthographic similarity, organization, and cueing (Bruce & Crowley, 1970; Forrester & King, 1971; Lauer & Battig, 1972; Pellegrino, 1974). Craik and Lockhart have suggested that these results would best be described by a "levels of processing" approach to memory. Within this framework, persistence of a memory trace is a function of the depth of perceptual analysis which it is given by the learner. Depth is determined by the meaning analysis and elaboration which is given to the stimulus rather than the amount of elaboration per se (Craik, 1973). Thus, "Type I" processing, which is repetition of analyses already carried out (i.e. rote rehearsal), does not lead to improved memory for the trace, but "Type II" processing, which involves elaborative meaning analyses, will. With such an approach, the total time spent on a task becomes less important than how that time is spent.

Recently, Craik and Tulving (1975) reported 10 experiments which confirm and extend the findings for levels of processing. When subjects were asked questions which led to a meaning analysis of a word, both recall and recognition were better than when the questions concerned structural characteristics. Questions leading to "yes" answers produced better performance than those with "no" answers, except where orthographic features were concerned, and then they were equal. This latter finding was said to be due to the larger "code elaboration" which occurred with semantic-yes questions. The failure to find a similar effect for the orthographic queries is probably due to the nature of the questions. Asking whether a word is in upper or lower case letters does not lead to a particularly unique definition for that word. The authors cited an unpublished study by Moscovitch and Craik where the original encoding questions were used as cues, and cueing facilitation was greater with the semantic ones. If, as they say, "the normal advantage to deeper levels is associated with the uniqueness of the encoded question-target complex," then the orthographic questions they used (as well as the tasks used by Hyde and Jenkins, 1969, 1973) might not be expected to be particularly helpful.

One of Craik and Tulving's final conclusions was that integrated encodings provide more elaborate traces and greater congruence with semantic memory which in turn facilitates the retrieval process. If this is true, then elaborate semantic encoding and cueing should help to improve the memory performance of older subjects who may suffer from problems of retrieval. Evidence for such beneficial influence of semantic encoding and retrieval strategies or any type of differential encoding is sparse in geriatric research.

Hultsch (1969) found that among his low-verbal ability subjects, the oldest group (45-54 years) performed worse than the younger adult subjects in a free recall task if previously given non-specific instructions to organize the list, but the two groups were equal in recall when instructed to organize the list alphabetically. Laurence and Trotter (1971) investigated paired-associate learning in young and older subjects of a mixed list of acoustically similar, unrelated, and homophone pairs. There was less of an age deficit only on the homophone pairs.

In another study of paired-associate learning, Hulicka and Grossman (1967) found that older subjects were much less likely to report the spontaneous use of mediators and that some of those they did report were inappropriate. Instructing subjects to form an image as a mediator produced a larger facilitative effect in the older than the young subjects. In his work on psycholinguistic performance, Riegel (1968) gave some of his subjects cues and asked them to guess the original stimulus or word. The cues for a word like "zebra" were either superordinates (animal), similars (horse), parts (stripes) or locations (Africa). Compared to the younger age groups (11.8 and 14.8 years), the older subjects (63 years) showed less of a deficit with single presentations and combinations of the part and location cues than the superordinate and similar cues. Riegel suggested that older subjects may have trouble dealing with the more abstract and logical relations, thus causing a preference for concrete forms of conceptualization.

After the present experiment was well under way, Eysenck (1974) reported an experiment on levels of processing in the elderly. Young and old subjects were given a 27-item list taken from nine taxonomic categories and were asked to perform one of four tasks on these words: count the letters, give rhymes, modify with adjectives, or form images. A fifth control group was told only to learn the words. The main results were significant age differences in recall favoring the young only for the semantic tasks, and the absence of differences between the semantic tasks and the intentional control for both age groups. The author concluded that the elderly are at a disadvantage on tasks requiring deeper levels of processing. However, the reason for this disadvantage was not clear, particularly in light of the Craik and Tulving (1975) conclusion that retrieval is aided by deeper or semantic levels of processing.

That Eysenck's older subjects were in fact still hampered by a retrieval problem was indicated by his analysis which showed more categories as well as more items per category recalled by the younger subjects. This age difference was larger for the semantic tasks in the case of items per category, although category clustering did not differ with age. The results are also made somewhat equivocal by the use of a categorized word list which has been shown to interfere with physical processing (Lauer & Battig, 1972; Mondani et al., 1973). In addition, rhyming and letter counting tasks did not produce different performances for either young or old subjects, although Craik and Tulving found large recognition differences favoring rhyming, supposedly due to the greater elaboration and integration provided between the target word and the task. Thus, although Eysenck's study presents some interesting and valuable data on processing by the elderly, several major issues remain to be clarified.

<u>Intent to Learn</u>

The results of studies on intent to learn in the aged have been questionable primarily due to methodological problems. Wimer (1960) asked subjects to read six different words and later asked them to recognize the color in which each word had appeared. Intent to learn the colors produced better recognition only for the younger subjects, and incidental-young subjects did not differ from the older subjects. In addition to the limited length of the list, the results are complicated by the use of a recognition procedure which has been found to attenuate general performance differences between young and old subjects (Schonfield & Robertson, 1966) as well as between incidental and intentional learning instructions (Estes & DaPolito, 1967). In another study which alluded to an incidental-intentional issue, Kausler and Lair (1965) had young and old subjects learn a list of paired-associates to the same criterion of forward recall and then asked for the backward associations. The older subjects were worse than the younger ones on this task, and the authors suggested that they may pay relatively more attention to intentional components of tasks than do the young, leaving less time for the incidental components. Eysenck's (1974) results indicate that intent to learn is not relatively more important for older people, although his comparisons were based on a single control group rather than intentionally instructed subjects under each of the different tasks. Thus, the interaction of intent with age and processing remains uninvestigated.

Methodological Variables

The results of several experiments have shown that experimental procedure may influence age performance differences. Thus, a brief digression on methodological variations will indicate why certain procedures were followed in the present study and may also provide a guide for future research.

It is common to administer pretests to subjects in geriatric studies, and these usually involve vocabulary and/or digit span tests. Both have been shown to decline little with age (Botwinick, 1967; Talland, 1968) and are thus used to demonstrate the comparability of the young and old groups prior to experimentation. However, vocabulary tests require the processing of word meanings, a factor which may interact with the experimental tasks, perhaps differentially so with age. Therefore, pretests should be designed to fit the requirements of the experiment, and other tests, such as problem solving or anagrams should be considered for use.

Performance differences due to age may also be affected by mode of presentation. Larger age decrements in recall have been found with visual compared to auditory presentation (McGhie, Chapman, & Lawson, 1965). Thus, it is suggested that where visual presentation is necessary, pronunciation should also occur (Arenberg, 1968).

Canestrari (1963) and others have shown that age differences are reduced by the use of selfpaced schedules for learning and recall tasks. This appears to be due to a general slowing of response with age, possibly caused by decline in the central nervous system (Botwinick, 1973). Riegel (1968) found longer reading times for elderly compared to young subjects, a factor which should be considered when response latencies to verbal materials are a concern.

A few studies have shown that performance differences between young and older subjects are decreased by the use of an oral instead of a written recall procedure (Talland, 1968; Clark & Knowles, 1973). The problem seems to be one of the older subject's difficulty in transposing acoustic messages to written ones as well as his inability to take advantage of cueing by words already written down. Despite this finding, many investigators of geriatric problems continue to use written recall procedures, thus possibly inflating actual differences between young and old learners. Originally, the manipulation of this variable had been planned for the present experiment. However, a few older pilot subjects demonstrated a complete unwillingness to use cues during written recall and exhibited a general defeatist attitude with this procedure. Thus, only oral recall conditions were used.

One final consideration is that of situational anxiety to which older persons may be relatively more susceptible than the young (Eisdorfer, 1968). In a paired-associate experiment by Ross (1968), a larger performance deficit due to age was obtained when instructions were challenging than when they were supportive. This implies the need for careful wording of instructions as well as a relaxed atmosphere during testing.

Rationale for the Experiment

The experiment described in this paper was designed to answer several questions concerning learning and memory in the elderly. Conceived within a "types of processing" approach to memory, both young and older adults served as subjects. All subjects learned the same list of words but differed in the kind of instructions they were given and hence the type of processing they did. There were two types of semantic processing, categoric and associative, and two types of physical processing, rhyming and orthographic. Thus, subjects gave either a category, a word association, a rhyme, or a unique letter description for each word. A fifth group was an individual condition in which the subjects were free to respond to the words in any manner they wished. Intent to learn was also manipulated within each task. After processing all the words in the list, an uncued free recall was followed by a cued recall, the cues being those responses the subject gave to each word during the processing task. A yes-no recognition test followed the cued recall.

One of the major concerns of the experiment was the effect of different types of word processing on recall and recognition performance in the elderly. Eysenck's (1974) recent study with British subjects showed that the old may be at a disadvantage at the "deeper" or semantic levels of processing. The present experiment allowed for the replication of this finding with unrelated words and four additional tasks, rhyming being the only one common to the two investigations. In addition, the cueing and recognition procedures were used to evaluate the notion of a retrieval deficit in the elderly. If Hultsch's (1975) conclusions based on a categorized word list are correct, then the old should experience a larger cueing facilitation than the younger subjects, particularly since the cues are individually generated by each subject, a procedure which is more effective than experimenter-supplied cueing (Schwarz, 1974). The cued recall as well as the recognition test may also indicate possible sources for any age differences in free recall which vary with the processing tasks.

The importance to the elderly subject of intent to learn was an additional issue in this investigation. Depending on the outcome of this variable, an interaction of intent with age and type of processing may be obtained. For example, intent may be relatively more important for older subjects regardless of type of processing, or it may only be important in those tasks which produce the poorer recall performance.

There were also questions of interest involving the college-age subjects. Although it is known that for them, semantic processing produces better recall than physical processing, there are few comparisons of different types of semantic processing. Such a comparison is related to the old issue of whether category clustering is determined by the superordinate nature of the category or the common associations of words within a category (Shuell, 1969). Since the words used in the experiment were ones for which the first free-associate was not the category name, a direct comparison of taxonomic with associative processing and cueing was made possible. Similarly, a comparison of two types of physical processing occurred, although previous studies suggest that the recall difference favoring the rhyming over the orthographic tasks might be larger than any difference between the two semantic tasks (Lauer & Battig, 1972; Nelson & Brooks, 1974). However, providing a unique orthographic determination for each word may make that type of processing as effective as rhyming.

The individual processing condition should provide data in both age groups on differences in processing both between and within individuals (Battig, 1975). Since there is evidence in the paired-associate literature that subjects perform better when free to use their own mediator rather than one which is experimenter-supplied, the individual condition might produce the best recall (Hulicka & Grossman, 1967; Mondani, 1973). In addition, a comparison of types and variety of responses given by the two age groups was possible. Thus, Riegel (1968) has shown that for one type of processing (associative), there is greater between-subjects variability in older compared to younger groups. However, whether this is true for different types of processing within individuals remains to be determined. According to Battig, flexibility often leads to superior performance, and thus its presence or absence in the elderly population may be a source of explanation for results obtained.

In summary, there are at least five major questions of concern in the present investigation.

1) What types of processing and cueing produce superior recall and recognition in elderly subjects, and which show the least performance decrement with age?

2) Do older subjects have retrieval problems which may be attenuated by the use of cueing and recognition test procedures?

3) Does intent to learn produce equivalent effects in young and older subjects, and how does it interact with type of processing in the elderly as compared to the young?

4) How do two types of semantic processing (categoric and associative) compare with each other, and how do rhyming and orthographic tasks differ in their effects?

5) What are the individual differences in responses between- and within-subjects in a free-responding situation, and how does individual processing affect recall?

CHAPTER II

METHOD

Design

The experiment was a 2x5x2 factorial design. The first factor was the age of the subjects, young or old, and the second was type of processing which was either categoric, associative, rhyming, orthographic, or individual. Incidental or intentional learning instructions constituted the third factor.

Subjects

The young subjects were 80 undergraduate students, 42 males and 38 females, who were enrolled in introductory psychology classes at the University of Colorado, and who participated in the experiment to fulfill a course requirement. Their mean age and education were 19.3 and 13.7 years respectively.

The older subjects were 80 volunteers age 60 or over who were living independently in Boulder, Colorado. There were 17 males and 63 females with a mean age and education of 70.7 and 14.1 years. Five more older subjects had to be discarded, four for failing to follow instructions, and one for expecting a recall test in the incidental condition.

All subjects were tested individually in small rooms at either the University, the Boulder Senior Citizen Center, or Golden West Manor, a retirement apartment complex. The testing of the elderly began and ended approximately two weeks prior to that of the young, with either young or old being run on successive days in the interim.

Materials

The learning list, shown in Table 1 along with the three practice words, was composed of 30 one-syllable nouns from 30 different taxonomic categories in the Battig and Montague (1969) category norms. Within their respective categories, the words ranged in rank from 1 to 24 with a mean rank of 8.27 and a mean taxonomic frequency of 185.10. The words were either four or five letters in length and began with 17 different initial letters. There were no more than two words beginning with the same initial letter, and for any such pair, the letter which occurred last in the alphabet in each word, excluding the initial letter, was different. For 21 of the words, it was determined from free-association norms for category responses that the primary associate was a word other than the category name (Marshall & Cofer, 1970; Schulz & Briton, unpublished), while the same was determined for the nine remaining words through the responses of pilot subjects. None of the learning words shared the same rhymes.

TABLE 1

LEARNING WORDS AND DISTRACTORS

Learning Words	Taxonomic Rank	Taxonomic Frequency	Distractor Words	Taxonomic Rank	Taxonomic Frequency
AUNT	1	432	NIECE	11	138
BOOK	2	370	TEXT	6	75
BRASS	9	97	GOLD	4	270
COAL	3	253	WOOD	4	223
CORN	3	247	PEAS	2	308
DRESS	8	240	COAT	7	260
DRILL	11	52	NAIL	3	248
FLEA	13	50	MOTH	12	62
FORK	3	359	BOWL	9	69
GRAPE	6	247	LIME	14	69
GREY	12	94	WHITE	8	272
HAIL	5	206	RAIN	3	297
HARP	12	105	FLUTE	6	246
INCH	3	411	YARD	4	362
JACKS	18	40	BLOCKS	8	98
JEEP	20	25	TRUCK	5	223
LAKE	6	98	STREAM	15	44
LAMP	6	227	DESK	5	230
MICE	10	118	DEER	12	95
MUMPS	7	115	FLU	15	48
NECK	14	120	KNEE	16	118
NURSE	9	47	CLERK	15	29
PEARL	5	177	JADE	7	84
PETE	24	49	MARK	20	51
ROME	17	36	PARIS	8	84
SALT	1	412	GARLIC	4	120
SWORD	6	110	KNIFE	1	405
TENT	3	189	HUT	5	121
WEEK	9	280	YEAR	4	424
WOOL	2	347	SILK	3	292
$\bar{X}$	8.27	185.10	$\bar{X}$	7.87	178.83
Practice Words			Practice Words		
DIME	3	261	COFFEE	5	225
GIN	3	308	MONK	12	76
MONK	12	76	VERB	4	330

Also shown in Table 1 is the list of distractors and practice words for the recognition test. For each word in the learning list, a distractor was chosen which was from the same taxonomic category as the learning word but which began with a different letter and had different rhymes. With the exception of three words, all the distractors had one syllable, and with the exception of four words, they had either four or five letters. As in the learning list, the distractors also began with 17 different initial letters, although two of these (Y and K) were new letters, and two from the learning list (A and I) were not included. The distractors ranged in rank within their categories from 1 to 20 with a mean rank of 7.87 and a mean taxonomic frequency of 178.83.

Procedure and Equipment

Table 2 is a summary of the procedure which was followed for each subject. After general instructions that the experiment was not a test of intelligence or personal ability, the two pretests were administered. The first of these was a forward digit span test in which random sequences of non-repeating digits were presented by Carousel projector with one second exposure per digit. Each digit was also verbally announced by the experimenter as it appeared. Presentation of the sequences started with four digits and continued until the subject failed to recall a sequence completely and

TABLE 2

EXPERIMENTAL PROCEDURE

A. <u>Pretests</u>

1. Digit span
2. Anagram problem

B. <u>Learning Experiment</u>

1. Word processing task
2. Uncued free recall
3. Cued recall
4. Yes-no recognition test

C. <u>Anxiety Report</u>

in order or until he recalled 10 digits correctly. Recall was oral and selfpaced. (The random sequences for these digits as well as all random word orders and instructions are available in the appendix.)

Immediately following the digit span test, four minutes was allowed for the second pretest which consisted of an anagram problem (Ammons & Ammons, 1959). The subjects were given a sheet of paper with the letters "A,B,E,M,T" printed at the top and were asked to write on the sheet as many English words as they could make up, using only these letters. They were told they didn't have to use all the letters in every word, they could use a letter more than once within the same word, and they should avoid the use of proper nouns. As an example, they were shown a sheet on which the letters "D,I,L,O,P" were printed and given the word "doll" as an appropriate response.

Results from the pretests were used to assign the subjects to the various experimental conditions. An effort was made to equalize the groups for proportions of high and low scorers to control for memory differences as well as abilities which might interact with the experimental variables.

Following the pretests, the subjects were given the processing task. The 30 words in the learning list were presented successively by Carousel projector in an order which was random with the restriction that two words with the same initial letter or obvious associations were not contiguous. To avoid modality problems, all subjects were instructed to pronounce each word as soon as it appeared. Subjects in the categoric group were told to also say for each word the name of the general class or category of things to which the word belonged, while for the associative condition, the subjects were instructed to say the first word which the projected word made them think of. Subjects assigned to the rhyming task were told to say a word which rhymed with the word being projected, and if they could not think of a rhyme, to make up a rhyming word. With orthographic instructions, the subjects were told to say the initial letter of the word and then the letter which occurred last in the alphabet excluding the initial letter. The word "herring" was given as an example to all four groups, with the corresponding example responses being "fish," "pickeled," "caring," and "HR" respectively.

The subjects in the individual processing condition were instructed in general concerning the various attributes that words are considered to possess and were told to respond to that property of each word which appeared most noticeable. They were given all four of the "herring" responses as examples as well as the assurance that whatever utterance or response they might wish to make would be perfectly acceptable.

Subjects in all five processing conditions were told that the purpose of the task was to see how accurately people can respond to words in the manner they had been instructed in a limited amount of time, so they were to be quick as well as precise. In order to encourage immediate pronunciation of the list words, they were told that the task was also a test of their reading speed. Intentional conditions were additionally instructed to remember the projected words for a later recall test.

All subjects were given 12 seconds to say each word and give the required response, after which the next word was immediately shown. If a subject did not respond within this time limit, the experimenter provided an appropriate response as two Hunter decade interval timers advanced the projector to the next slide. The subjects were asked to practice on three words prior to list presentation.

Responses given during the processing task were tape recorded for later determination of processing times. The latter was done by manually timing with a Hunter Klockounter the interval between word pronunciation and task response, thus avoiding the contamination of the latencies with differences in reading speed. Using this method, the experimenter independently measured the processing times twice, and an average time was obtained for each word.

After the processing task and a 30-second delay interval, all subjects were given an oral unpaced free recall, followed by an unpaced cued recall, the cues being the responses each subject gave to the words during processing. These cues had been written by the experimenter in a predetermined random order on a sheet which was given to the subjects. They were instructed to read each cue outloud and say the learning word which went with the cue. After going through all the cues, they were allowed to go back to missed items or say additional words for which they did not remember the cues. There were no explicit instructions regarding guessing.

A forced-choice yes-no recognition test followed the cued recall. Each distractor and target was presented by itself on a slide long enough for the subject to say the word, indicate whether he'd seen it before, and give a confidence rating of one to four on his decision. The words appeared in random order with the restriction that no more than three targets or distractors were contiguous. In addition, from 20 to 38 items intervened between a target and its corresponding distractor. The recognition test was oral and selfpaced, and all subjects were asked to practice on three words prior to list presentation.

The anxiety report was the final task of the experiment. Each subject was asked to read and answer outloud the following question which was printed on a small card: "How much anxiety, apprehension, or concern did you experience while performing the tasks in this experiment? Choose one: none, mild, moderate, strong, extreme." Subjects in the incidental conditions were then asked if they had expected the recall tests.

CHAPTER III

RESULTS

Results are described in three sections. The first of these is subject assignment and covers the potential subject variables of numerical age and education as well as pretest results. In the second section on experimental variables, results for most of the various performance measures are described. Any other results are presented in a third miscellaneous section.

Unless otherwise noted, all dependent variables were analyzed by multifactor analyses of variance, for which the minimum probability level required for significance was .05. The F values for these analyses are available in the appendix, and, except for individual comparisons and a few minor analyses, only probability levels will be reported in the body of the text. Individual condition means for the major analyses are also given in the appendix.

Subject Assignment

Numerical age and education. Although age was manipulated as an experimental variable, the broad classes of young and old subjects allowed for possible variation in numerical age within the experimental groups, particularly among the older subjects. However, separate analyses for young and old subjects revealed no significant differences in numerical age in either group among the various processing and instruction conditions and their combinations, $Fs \leq 1.39$, $p > .20$. In addition, a combined analysis showed no significant differences in years of education between young and older groups nor any of the other experimental conditions, $Fs \leq 2.80$, $p > .09$.

Pretests. For each subject, the digit span pretest was scored for the largest number of digits reported in the correct forward order. Young subjects recalled significantly more digits (5.99) than old subjects (5.24), $p < .001$, but there were no other significant effects among the experimental groups, $Fs < 1.43$, $p > .20$.

Each subject's score on the anagram pretest was determined by the total number of different English words, excluding proper nouns, which the subject constructed from the letters provided. Although older subjects had slightly fewer words (15.03) than the younger subjects (16.00), there were no significant differences obtained, $Fs \leq 2.38$, $p > .10$.

Since the range of the anagram test was generally about twice that of the digit span, the latter score was doubled and added to the former and used as a basis for subject assignment to the experimental groups. Analyses of variance of these combined scores indicated a significant difference in favor of the younger subjects, $p < .01$, but no other experimental variable produced a significant effect (all Fs < 1).

Pearson product moment correlations between the pretests and numerical age and education were calculated separately for young and old subjects. These were uniformly small and nonsignificant for the young group (rs $\leq \pm .06$). However, for the older subjects there were significant negative correlations between age and the pretests (rs $= -.24$, $p < .05$) except for the digit span ($r = -.12$, $p > .05$). There were positive correlations between education and all three pretest measures in the older group which were significant on the digit span and combined test (rs $= .28$, $p < .05$) but not the anagram ($r = .20$, $p > .05$). Thus, for the older subjects, decreasing age and increasing education were associated with better pretest performance.

Experimental Variables

In this section, results for analyses of variance for several different performance measures will be described separately for the three experimental variables of age, instructions, and processing. For the age and instruction variables, primarily main effects will be reported, since most significant interactions involved the processing conditions.

The performance measures fall into three broad categories: recall, recognition, and organization. The first category includes list words and intrusions given on the free (FR) and cued (CR) recalls, cued-free recall difference scores, and a measure of cueing advantage. The latter was obtained from each subject's recall by the following formula: (CR-FR)/(30-FR). Also analyzed were the proportions of words recalled from the first six, middle 18, and last six items of the list and average word processing times for recalled and non-recalled words on the free recall test.

Percent correct recognition and area under the receiver operating characteristic (ROC) were the measures of recognition memory. The former was defined as follows: (hits + correct rejections)/60. The area score measure was derived from a signal detection analysis of the hit and false alarm data for each subject (Green & Swets, 1966), with 1.00 representing perfect recognition. Two measures were also employed to determine differences of bias in responding. The average confidence rating assigned to hits and correct rejections were calculated separately and analyzed as a repeated measure, and the signal detection measure of criterion (β) was computed for each subject based on tables provided by Hochhaus (1972).

Two types of organization on the free recall were examined: seriation and input-output. Seriation measured each subject's tendency to order his recall according to the input order of just the recalled items, while input-output measured the same ordering but included all 30 words as the input standard. This made the maximum possible organization smaller by adjusting for non-recalled items. Both measures were derived from Pellegrino (1971) and were expressed in ARC scores which generally range from -1.00 to +1.00, zero and +1.00 representing chance and perfect organization respectively. Unidirectional as well as bidirectional organization were examined, but due to the single free recall trial and sparsity of data, only subjective organization units of size two were measured.

Main effects of age. For the performance measures just described, any significant main effects of age were accompanied by significant interactions of age with processing. These interactions will be described in the processing section below.

Young subjects recalled significantly more words on both the free and cued recalls (8.14 and 18.41) than did the older subjects (5.37 and 16.27), both $p < .001$. The interaction of age with recall test was not significant ($p > .10$) and neither was the effect of age on cued-free recall difference scores, $p > .10$. However, a significantly larger cueing advantage was enjoyed by the young subjects (.515) compared to the older group (.458), $p < .05$. There were no significant effects of age in proportion recalled from first, middle, and last sections of the list. Average word processing times were significantly longer for the old (2129 msec) than the young (1788 msec), $p < .01$, but there were no interactions of age with processing times for recalled versus non-recalled items. Older subjects gave more intrusions on both the free and cued recalls (1.43 and 6.36) than the young (1.03 and 3.40), a difference which was significant only on the cued recall ($p < .001$) and which produced a significant interaction of age with recall tests ($p < .001$).

Both percent correct recognition and area scores were significantly larger for the young (.917 and .940) than the old (.874 and .907), $p < .001$, but age produced only significant interactions in the analyses of confidence ratings and β. There were no main effects of age in the analyses of seriation, although this showed significant interactions of age with processing and instructions, while the input-output measure had neither.

Main effects of instructions. The only analysis where instructions produced a significant main effect which did not interact with processing was in free recall where incidental groups were significantly lower (6.06) than intentional conditions (7.45), $p < .01$. However, there were no significant effects of instructions in the cued recall analysis. Incidental subjects gave more intrusions on the free and cued recalls (1.59 and 5.43) than did intentional (.86 and 4.34), with this difference significant only on the free recall, $p < .001$.

Instructions produced no significant main effects in any of the recognition, processing time, or organization analyses, but there were significant interactions with processing for all but the percent correct recognition measure. There were no significant interactions of instructions with age which did not also involve the processing variable.

Processing. All significant main effects and interactions involving processing were analyzed by four planned orthogonal comparisons: categoric, associative, and individual (semantic) versus rhyming and orthographic (physical), categoric versus associative, both of these versus individual, and rhyming versus orthographic.

Semantic versus physical processing. Mean recall measures for semantic and physical processing groups are given in Table 3. Significantly greater free and cued recall, cueing advantage, and cued-free recall difference scores were found for semantic than physical processing, Fs (1,140) $\geq$ 104.36, $p < .001$. For all four measures, this one comparison accounted for 93% or more of the variance associated with the main effect of the processing variable. The interaction of semantic versus physical with age was significant for all but the difference score measure Fs (1,140) $\geq$ 5.17, $p < .025$. In each case, the superiority of the young over the old was much smaller in the physical conditions. This was confirmed by simple contrasts of the means whereby the young

TABLE 3

MEAN RECALL AND RECOGNITION MEASURES FOR SEMANTIC AND PHYSICAL PROCESSING CONDITIONS

Condition		Measure				
		Free Recall	Cued Recall	Cueing Advantage	Percent Recognition	Area Score
Semantic	Young	10.63	25.02	.752	.964	.977
	Old	6.73	21.71	.647	.937	.956
	$\bar{X}$	8.68	23.37	.699	.950	.967
Physical	Young	4.41	8.50	.160	.847	.885
	Old	3.34	8.13	.175	.779	.832
	$\bar{X}$	3.87	8.31	.167	.813	.858

Mean processing times were significantly longer for recalled (2291 msec) than non-recalled words (1878 msec) in the overall analysis, $p < .001$. As shown in Table 4, this difference was larger in the semantic condition with incidental instructions, but with physical processing it was greater with intentional, causing a significant interaction of the two processing types with recalled and non-recalled items and instructions, $F(1,140) = 9.87$, $p < .01$.

In the overall analysis of intrusions, significantly more occurred on the cued (4.88) than the free recall (1.23), $p < .001$. As Table 5 indicates, more intrusions were given on both tests by physical than semantic processing conditions, although the effect was much larger on the cued than the free recall, Fs $(1,140) = 161.78$ and 5.88, ps $< .001$ and $.05$. As described earlier, older subjects had significantly more intrusions than the young only on the cued test, a difference which was greater with physical than semantic processing, $F(1,140) = 16.37$, $p < .001$. On the free recall, the age differences were similar for both processing conditions, causing a significant interaction of semantic versus physical processing with age and recall test, $F(1,140) = 16.31$, $p < .001$. A further breakdown indicated the age difference on the cued recall to be slightly larger with intentional instructions in the physical group but with incidental in the semantic

TABLE 4

MEAN WORD PROCESSING TIMES IN MSEC FOR RECALLED AND NON-RECALLED WORDS ON THE FREE RECALL TEST FOR DIFFERENT PROCESSING COMPARISONS

Condition		Recalled Words	Non-recalled Words
Processing	Instructions		
Semantic	Incidental	2080	1619
	Intentional	1662	1440
	$\bar{X}$	1871	1515
Physical	Incidental	2362	2256
	Intentional	3480	2545
	$\bar{X}$	2921	2401
Rhyming	Incidental	2573	2383
	Intentional	4589	2642
	$\bar{X}$	3581	2513
Orthographic	Incidental	2151	2129
	Intentional	2371	2447
	$\bar{X}$	2261	2288

TABLE 5

MEAN INTRUSIONS FOR DIFFERENT PROCESSING COMPARISONS

Condition		Recall Test and Processing			
		Free		Cued	
Age	Instructions	Semantic	Physical	Semantic	Physical
Young	Incidental	1.33	1.63	1.87	8.44
	Intentional	.33	1.00	.58	4.87
	$\bar{X}$	.83	1.31	1.23	6.66
Old	Incidental	1.42	2.19	2.92	11.50
	Intentional	1.00	1.31	1.42	13.81
	$\bar{X}$	1.21	1.75	2.17	12.66
	$\bar{\bar{X}}$	1.02	1.53	1.70	9.66
Age	Instructions	Rhyming	Orthographic	Rhyming	Orthographic
Young	Incidental	2.37	.87	10.75	6.13
	Intentional	1.13	.87	5.50	4.25
	$\bar{X}$	1.75	.87	8.13	5.19
Old	Incidental	2.13	2.25	11.00	12.00
	Intentional	2.25	.37	18.75	8.87
	$\bar{X}$	2.19	1.31	14.87	10.44
	$\bar{\bar{X}}$	1.97	1.09	11.50	7.81

condition, a pattern which was exactly reversed on the free recall. In addition, the previously noted greater frequency of intrusions with incidental compared to intentional instructions was reversed only in the old-physical cued condition. These results produced a significant interaction of semantic versus physical processing with age and instructions on the cued recall as well as the interaction of those three variables with recall tests, $Fs\ (1,140) \geq 5.91$, $p < .025$.

Percent correct recognition and area scores were significantly larger with semantic than physical processing, $Fs\ (1,140) \geq 168.67$, $p < .001$, and this comparison contributed 93% or more of the variance associated with the overall main effect of processing for the measures. (See Table 3.) Simple contrasts of the means showed the superiority of the young in recognition performance to be smaller with semantic ($Fs \leq 5.00$, $p < .05$) than with physical processing ($Fs \geq 16.33$, $p < .001$). This was confirmed by the interaction of age with the two processing types which was significant in the percent correct recognition measure, $F\ (1,140) = 4.60$, $p < .05$, and approached significance in the area score analysis ($p < .10$). The pattern for these age differences is opposite that found for free and cued recall, but coincides with the large amount of intrusions found for old subjects in the physical cued conditions.

Table 6 shows that confidence ratings with

TABLE 6

MEAN CONFIDENCE RATINGS FOR SEMANTIC AND PHYSICAL PROCESSING CONDITIONS

Instructions	Age	Processing: Semantic	Processing: Physical
Incidental	Young	3.91	3.42
	Old	3.86	3.62
	$\bar{X}$	3.89	3.52
Intentional	Young	3.88	3.67
	Old	3.89	3.61
	$\bar{X}$	3.89	3.64
	$\bar{\bar{X}}$	3.89	3.58

semantic processing were greater than with physical, a difference which was highly significant, F (1,140) = 106.82, $p < .001$. Within the semantic condition, age-instruction subgroups were approximately equal in confidence, while with physical processing, the young-incidental subjects were below the other three groups. This effect, which may be related to the relatively large amount of cued recall intrusions by these subjects (Table 5), produced significant interactions of semantic versus physical processing with instructions and with age and instructions, Fs (1,140) $\geq$ 3.90, $p < .05$. However, there were no significant interactions of the two processing types with hits versus correct rejections nor were there any significant effects for this comparison in the analysis of β.

In the organization analyses, bidirectional seriation was slightly greater for incidental than intentional instructions for both the young- (.064 and .043) and the old- (.066 and .049) semantic groups as well as the old-physical group (.094 and .072). However, incidental was below chance (-.142) and less than intentional in the young-physical group (.220), which also had a much larger amount of bidirectional seriation than the other conditions. Thus, semantic versus physical processing interacted with instructions and with age and instructions, Fs (1,140) $\geq$ 4.07, $p < .05$, and these were the only significant effects in the bidirectional seriation analysis, as well as the only effects of this comparison on organization.

Categoric versus associative processing. This comparison produced significant effects only in the recall and organization analyses. Mean recall measures for age and processing conditions are shown in Table 7. In free recall, categoric was superior to associative processing in the young subjects, but the two were equivalent in the older group, causing a much larger age difference in the categoric condition. Thus, the main effect of categoric versus associative processing as well as the interaction with age was significant, Fs $(1,140) \geq 5.17$, $p < .025$. Similar patterns of results were obtained in the cued recall analysis, but there were no significant effects, Fs $(1,140) = 3.33$ and 1.58, $p < .10$ and $> .20$. Cueing advantage was significantly larger with categoric than associative processing, $F\ (1,140) = 4.20$, $p < .05$, and while this difference was again much smaller in the older group, the interaction was not significant ($p > .10$). There were no significant effects on cued-free recall difference scores (Fs < 1) nor in the recognition analyses (Fs ≤ 1.11).

In the overall analysis of proportion recalled from first, middle, and last sections of the list, there was a significant main effect of sections with mean proportions of .135, .210, and .361 respectively, $p < .001$.

TABLE 7

MEAN RECALL AND WORD PROCESSING TIME MEASURES
FOR AGE AND PROCESSING CONDITIONS

Condition		Measure			
Processing	Age	Free Recall	Cued Recall	Cueing Advantage	Processing Time (msec)
Categoric	Young	12.63	27.06	.848	1572
	Old	6.56	22.25	.673	2024
	$\bar{X}$	9.59	24.66	.761	1798
Associative	Young	9.25	24.00	.713	1417
	Old	6.63	21.69	.640	1571
	$\bar{X}$	7.94	22.84	.677	1494
Rhyming	Young	4.56	10.87	.249	2783
	Old	2.19	8.56	.230	2443
	$\bar{X}$	3.37	9.72	.239	2613
Orthographic	Young	4.25	6.13	.071	1710
	Old	4.50	7.69	.120	2874
	$\bar{X}$	4.37	6.91	.096	2292
Individual	Young	10.00	24.00	.695	1457
	Old	7.00	21.19	.628	1735
	$\bar{X}$	8.50	22.59	.662	1596
	$\bar{X}$	6.76	17.34	.487	1959

The linear component accounted for 96% of this variance, $p < .001$. As shown in Table 8, the superiority of intentional over incidental instructions in free recall was limited to the first six items in the list in the categoric conditions, but involved the last items in the associative groups. This produced the only other significant effect in this analysis, the interaction of categoric versus associative processing with instructions and sections, $F\ (2,280) = 3.39$, $p < .05$, the linear component again being significant, $F\ (1,140) = 6.10$, $p < .025$.

There were no significant effects obtained in the overall analysis of unidirectional input-output organization on the free recall, and the only one significant in the bidirectional analysis was the interaction of categoric versus associative processing with instructions, $F\ (1,140) = 4.84$, $p < .05$, shown in Table 8. There was much more organization with associative than categoric processing with intentional but not incidental instructions.

Categoric and associative versus individual processing. This comparison produced no significant effects in any of the analyses reported in this section.

Rhyming versus orthographic processing. There were no significant effects of this component in free recall, although rhyming was inferior to orthographic processing for the old but not the young, $F\ (1,140) =$

TABLE 8

MEAN PROPORTION RECALLED FROM FIRST AND LAST LIST ITEMS AND MEAN BIDIRECTIONAL INPUT-OUTPUT ARC SCORES FOR CATEGORIC AND ASSOCIATIVE PROCESSING CONDITIONS

Condition	Proportion Recalled First	Proportion Recalled Last	Bidirectional ARC
Categoric			
Incidental	.167	.438	.173
Intentional	.250	.437	-.074
Associative			
Incidental	.156	.334	.111
Intentional	.156	.510	.345

3.25, $p < .10$. However, rhyming did produce significantly greater cued recall, cueing advantage, and cued-free recall difference scores than did orthographic processing for both age groups, $Fs\ (1,140) \geq 8.03$, $p < .01$. (See Table 7.) On the repeated free and cued recall analysis, combined recall was better with rhyming than orthographic processing for the young subjects (7.72 and 5.19), while in the older group, orthographic was better (5.38 and 6.09), a result which reversed the general superiority of the young in the orthographic condition. There was also a generally larger increase from free to cued recall for the rhyming compared to the orthographic groups. These findings are supported by the significant interactions of the two processing types with age, $F\ (1,140) = 5.13$, $p < .05$ and with recall tests, $F\ (1,140) = 14.95$, $p < .001$.

As indicated in Table 7, average word processing times were longer for rhyming than orthographic processing in the young, but for the older subjects, the opposite occurred. Rhyming was the only one of the five processing conditions in which the processing times were shorter for the old than the young. In the analysis of this measure, the main effect of rhyming versus orthographic processing fell short of significance ($p < .10$), but the interaction with age was highly significant, $F\ (1,140) = 15.19$, $p < .001$. Table 4 (p. 41) gives mean word processing times separately for rhyming and orthographic instructional subgroups. Processing times were similar for recalled and non-recalled items in all but the rhyming-intentional condition where the recalled items took much longer. This result produced in the present comparison a significant interaction of recalled versus non-recalled items with processing and with processing and instructions, $Fs\ (1,140) \geq 12.36$, $p < .001$. It is related to the semantic-physical comparison, wherein the physical-intentional subgroup had the largest time difference favoring recalled items.

Table 5 (p. 42) shows the generally larger occurrence of intrusions with rhyming than orthographic processing. The previously noted greater frequency of intrusions by older subjects was eliminated in the rhyming-incidental and orthographic-intentional subgroups on the free recall. On the cued recall, the age difference was maintained but was much larger in the rhyming-intentional condition. This was due to the greater free to cued intrusion increase with rhyming, the difference being largest for young-incidental and old-intentional subjects. This pattern helps explain the semantic-physical comparison where a large amount of intrusions occurred for the same two subgroups given physical processing.

The reliability of the above results was supported by the rhyming-orthographic analyses of intrusions which showed for both recalls, significant main effects of processing, $Fs\ (1,140) \geq 7.21$, $p < .01$, and significant interactions of processing with age and instructions, $Fs\ (1,140) \geq 6.21$, $p < .025$. In the repeated measure analysis, the interaction of processing with recall tests was significant, $F\ (1,140) = 8.60$, $p < .01$, as was the four-way interaction with tests, age, and instructions, $F\ (1,140) = 8.22$, $p < .01$.

Mean recognition and area scores for all age and processing conditions are shown in Table 9. For both measures, rhyming was superior to orthographic processing in the young, but the two were equivalent in the old, causing significant main effects of rhyming versus orthographic processing, $Fs\ (1,140) \geq 10.67$, $p < .01$, and significant interactions with age, $Fs\ (1,140) \geq 10.78$. The latter accounted for 63% or more of the variance due to the overall age by processing interaction and suggests the source for the larger age difference in recognition which was obtained with physical compared to semantic processing. A further breakdown of area scores, shown in Table 10, indicates the superiority of the young to be greatest in the rhyming-intentional condition and actually reversed in the orthographic-intentional subgroup, making the three-way interaction significant, $F\ (1,140) = 6.37$, $p < .025$. It should be noted that within each separate age and processing condition, the lower score obtained for incidental or intentional instructions was associated

TABLE 9

MEAN RECOGNITION MEASURES FOR AGE AND PROCESSING CONDITIONS

Condition		Measure			
Processing	Age	Percent Recognition	Area Score	Confidence Rating	Criterion (β)
Categoric	Young	.978	.984	3.93	2.15
	Old	.926	.953	3.89	1.68
	$\bar{X}$	.952	.969	3.91	1.92
Associative	Young	.955	.972	3.90	2.09
	Old	.934	.957	3.85	3.10
	$\bar{X}$	.945	.964	3.87	2.60
Rhyming	Young	.900	.927	3.68	3.09
	Old	.781	.832	3.67	3.00
	$\bar{X}$	.841	.879	3.67	3.05
Orthographic	Young	.794	.842	3.41	1.87
	Old	.777	.832	3.56	2.34
	$\bar{X}$	.785	.837	3.48	2.10
Individual	Young	.958	.977	3.85	1.64
	Old	.950	.959	3.90	1.18
	$\bar{X}$	.954	.968	3.87	1.41
	$\bar{X}$	.895	.923	3.76	2.22

TABLE 10

MEAN RECOGNITION MEASURES FOR RHYMING AND ORTHOGRAPHIC INSTRUCTIONAL SUBGROUPS

Processing	Instructions	Age	Area Score	Confidence Rating	Criterion (β)
Rhyming	Incidental	Young	.908	3.62	2.51
		Old	.854	3.73	4.65
		$\bar{X}$	.881	3.67	3.58
	Intentional	Young	.946	3.74	3.68
		Old	.810	3.61	1.36
		$\bar{X}$	.878	3.67	2.52
Orthographic	Incidental	Young	.841	3.22	1.57
		Old	.808	3.51	1.34
		$\bar{X}$	.824	3.37	1.45
	Intentional	Young	.842	3.59	2.16
		Old	.857	3.61	3.34
		$\bar{X}$	.850	3.60	2.75

with a higher score in intrusions. (See Table 5.)

Mean confidence ratings for hits and correct rejections were significantly higher in the rhyming than the orthographic conditions, F (1,140) = 17.03, $p < .001$, a result which parallels percent correct recognition and area scores. However, as is shown in Table 10, the source for this difference was in the orthographic-incidental condition which had less confidence than the other three groups formed from the interaction of rhyming and orthographic processing with instructions, F (1,140) = 6.26, $p < .025$. In the overall analysis which included all processing conditions, there was significantly more confidence expressed in hits (3.81) than in correct rejections (3.72), $p < .001$. This effect interacted only with rhyming versus orthographic processing such that hits were equivalent to rejections with rhyming (3.69 and 3.66) but were greater than rejections with orthographic processing (3.59 and 3.37), F (1,140) = 8.98, $p < .01$.

In the analysis of criterion or β, the only significant effects involved the rhyming versus orthographic component which interacted with instructions and with age and instructions, Fs (1,140) $\geq$ 4.03, $p < .05$. The young had higher criteria than the old in the rhyming-intentional and orthographic-incidental conditions, but the reverse was true for the other two groups (Table 10). The pattern of the means indicates for these conditions a possible association between higher area scores and criterion scores and fewer intrusions.

While the semantic versus physical comparison produced the only significant effects in bidirectional seriation, the present comparison caused the only ones in the analysis of unidirectional seriation. Above chance unidirectional seriation was observed for young subjects in the orthographic incidental and intentional conditions (.347 and .069) but occurred for older subjects in the rhyming-incidental (.222) and orthographic-intentional groups (.136). This caused the significant interactions of rhyming versus orthographic processing with age and with age and instructions, $\underline{F}$s $(1,140) \geq 8.31$, $\underline{p} < .01$, which were the only significant effects of this comparison on organization.

<u>Other Results</u>

<u>Correlations</u>. Pearson product moment correlations were calculated between several variables and the performance measures of free and cued recall and percent correct recognition. For years of education, these correlations were negative but nonsignificant in the younger group ($\underline{r}$s $\leq -.20$, $\underline{p} > .05$) and positive but nonsignificant for the older subjects ($\underline{r}$s $\leq .15$, $\underline{p} > .05$).

Table 11 shows the correlations obtained between the pretest scores and the performance measures for young and old groups as well as for separate processing conditions. In general, the digit span and anagram

TABLE 11

CORRELATIONS BETWEEN PRETEST SCORES AND MEMORY PERFORMANCE

Correlation Variables	Experimental Conditions											
			Categoric		Associative		Rhyming		Orthographic		Individual	
	Young	Old	Young	Old	Young	Old	Young	Old	Young	Old	Young	Old
<u>Digit Span</u>												
Anagram Test	.00	.29*	-.20	.30	.24	.35	.11	.74*	.09	.26	-.06	-.04
Free Recall	-.03	-.08	.13	.42	-.37	-.29	.27	-.07	-.11	.17	.00	-.34
Cued Recall	.06	.06	.21	.61*	.14	.03	.40	.38	.15	.17	.03	.12
% Recognition	.12	.00	.21	.33	.23	.02	.37	.18	.28	.00	.18	.05
<u>Anagram Test</u>												
Free Recall	.21	.18	.13	-.07	-.02	.05	.56*	.16	.15	.37	.61*	.42
Cued Recall	.17	.22*	.31	.05	.07	.28	.61*	.52*	.60*	.36	.45	.49
% Recognition	.26*	.15	.23	.05	.62*	.22	.50*	.17	.26	.06	.40	.30
<u>Combined Pretests</u>												
Free Recall	.15	.10	.20	.13	-.17	-.09	.57*	.07	.04	.37	.47	.48
Cued Recall	.17	.20	.42	.31	.14	.23	.69*	.49	.54*	.37	.37	.48
% Recognition	.29*	.18	.35	.18	.61*	.18	.59*	.19	.36	.05	.44	.28

*$p < .05$, two-tailed test

tests were more positively related to memory performance in the old compared to the young subjects. However, the anagram test was a better predictor of performance in both age groups, with significant positive correlations being obtained for this variable. In addition, positive correlations between the anagram test and free and cued recall were generally higher with rhyming, orthographic, and individual processing, conditions which could be expected to involve more physical processing than the other two. However, there was no evidence that these processing correlations were higher for the old than the young, and if anything, the opposite was probably true.

Average word processing time was negatively correlated with all three performance measures in both age groups such that greater task time was associated with poorer performance. The correlations for free and cued recall and percent correct recognition were -.35 and -.41 (both $p < .01$) and -.11 ($p > .05$) in the young and -.41, -.47, and -.42 (all $p < .01$) in the old. Separate processing time correlations for the different processing conditions revealed only three positive ones for free and cued recall ($rs \leq .08$) and three for the recognition measure ($rs \leq .22$), none of which were significant.

Relative index of priority. Output priority was calculated for the individual list items which were given on the free recall test, using the technique suggested by Flores and Brown (1974). With this measure, a relative index of priority (RIP) is calculated separately for each word, with +1.00, 0, and -1.00 indicating that the item was recalled in the first, middle, or last part of the other recalled words. (Single word free recalls were excluded from the tabulations.)

Mean RIP scores were obtained for the 30 list words separately for the young and old conditions to determine any general differences in output priority for the two groups. The young and old subjects agreed on the sign of the RIP scores for 60% of the first six items in the input list, 39% of the middle 18 items, and 83% of the last six items. The mean RIP scores for first, middle, and last items were -.129, -.054, and +.180 in the young and -.213, -.045, and +.125 for the old, indicating a similar output distribution for the two groups, with last items generally being output first.

<u>Task performances</u>. The five processing tasks differed in the overt performance they required of the subject. For each of these tasks, subject responses were examined separately to determine any general age differences. Table 12 shows the measures used for categoric, associative, and rhyming conditions. In all three cases, there was slightly more variability in the old than the young, when number of different responses per word was considered. However, percent of subjects

TABLE 12

MEASURES FOR TASK PERFORMANCES BY YOUNG AND OLD SUBJECTS

Task	Age	$\bar{X}$ number of different responses per word	$\bar{X}$ % of subjects giving the same response per word	Number of subjects for which experimenter gave response	Number of words for which young and old agreed on most common response
Categoric	Young	2.40	81.1	2	29
	Old	2.97	73.4	5	
Associative	Young	8.30	36.1	0	18
	Old	8.83	33.7	2	
Rhyming	Young	7.23	33.6	8	13
	Old	7.57	33.8	5	

giving the same response to a word was larger for the young only in the categoric and associative conditions, with the two age groups being equivalent on the rhyming task. Experimenter-provided responses were also greater for the old in the two former processing conditions but less with rhyming. This result corroborates the longer processing times reported earlier for young subjects in the rhyming conditions, since by necessity, experimenter responses had the longest latencies.

It should be noted that for associative and rhyming conditions, there were several words for which the two age groups did not agree on the most common response given. For the categoric task, there was only one word for which disagreement was obvious. To the young, "hail" meant a weather occurrence, but for the old, it implied a greeting. In addition, for three words, the older subjects gave one of two responses as the category, the first of which was the sole common response by younger subjects: "corn" - vegetable and grain, "salt" - seasoning and condiment, "tent" - camping equipment and shelter.

By necessity, the responses given in the orthographic task were similar. However, there were some instances of incorrect letter analyses by the subjects, which were nonetheless used as the cues for those words. The younger subjects made more of these errors (2.88) than did the older group (1.56), although the difference fell short of significance, F (1,28) = 4.10, $p < .10$. This result may explain the superiority of the old over the young on the cued recall in the orthographic condition.

Table 13 shows the breakdown of responses given by subjects in the individual condition. The distributions are similar for the two age groups, with associative responses being the mode. Further breakdowns of different types of responses indicated only one obvious difference. Within the younger condition, 41% of the associative responses were property descriptions, and 37% were instances from the same taxonomic category as the list word, while for the old, these percentages were 62 and 17 respectively. (For each age group, another 19% of the associative responses were sequential.) Overall, young subjects used more different response types (6.56) than did the older group (5.50), although this difference was not significant, F (1,28) = 3.00, $p < .10$. The mean largest number of responses of a single given type was 12.13 for the young and 15.87 for the old, a difference which was significant, F (1,28) = 5.28, $p < .05$, and which indicated less response type variability within the older group.

Correlations between number of different response types and free and cued recall and percent correct recognition were negative but nonsignificant for the young-individual subjects (rs = -.36, -.06, and -.06)

TABLE 13

MEAN PERCENTAGES OF DIFFERENT RESPONSE TYPES
IN INDIVIDUAL PROCESSING CONDITIONS

Age	Response Type				
	Categoric	Associative	Rhyming	Orthographic	Other
Young	17.1	74.4	6.3	1.9	.4
Old	18.7	72.7	7.7	.8	0.0

but positive for the older group (_r_s = .00, .37, $p > .05$; .69, $p < .01$). Thus, for the older subjects, greater variability in response type was associated with better memory performance, particularly in cued recall and recognition. With largest number of a single response type as the variable, the correlations were positive but nonsignificant for the young (_r_s ≤ .11) and negative for the old (_r_s = −.12, $p > .05$; −.58 and −.64, _p_s < .05 and .01), indicating again the detrimental effect of homogeneity in the older age group.

Anxiety analysis. The responses to the anxiety report were none, mild, moderate, strong, or extreme. They were assigned numerical values of one through five for purposes of analyses of variance. The old reported significantly less anxiety (1.83) than did the young (2.31), $p < .001$. The only other significant effect was the interaction between rhyming versus orthographic processing and instructions, $F\ (1,140) = 4.60$, $p < .05$. Orthographic-incidental and intentional and rhyming-incidental subjects gave similar anxiety reports (2.19, 2.44, and 2.25) while subjects in the rhyming-intentional condition reported somewhat less (1.69).

In another analysis, the older subjects were assigned to one of two age groups: above or below the median age of 71. (Two of the seven age-71 subjects from different processing conditions were randomly assigned to the below-the-median group.) A one-way analysis of variance of these two older groups indicated significantly more anxiety reported by the below-71 subjects (2.03) than above-71 subjects (1.63), $F(1,78) = 5.63$, $p < .025$, a result which confirmed the age trend found in the overall analysis described above.

Correlations between reported anxiety and free and cued recall and percent correct recognition were significantly negative for the young subjects ($rs \geq -.31$, $p < .05$), while they ranged from -.04 to .02 in the old. Thus, greater reported anxiety meant poorer performance only in the younger group. There were few significant correlations in the separate age and processing conditions, and these did not deviate from the overall trends.

CHAPTER IV

DISCUSSION

Since the major purpose of this study was the investigation of age differences in learning and memory, this section begins with a summary of the results as they relate to the age variable. It is followed by a discussion of those findings which require further explanation and comment.

General Summary

In pretest performance, the young were significantly better than the old only on the digit span. The two were similar on the anagram task which also proved to be more positively related to subsequent memory performance.

The young were superior in free and cued recall and cueing advantage only with semantic processing which was better than physical for the old as well as the young. Categoric free recall was greater than associative in the young, but they were equivalent in the old, while cueing advantage was larger with categoric for both ages. Rhyming produced more cued recall and cueing advantage than orthographic processing for both ages, although on the free recall, orthographic was insignificantly superior in the older group. The free to cued recall increase did not interact with age, but was larger with semantic compared to physical processing and rhyming compared to orthographic. Intentional instructions produced better memory performance than incidental only on the free recall, an effect which did not significantly interact with age or processing.

The old had longer word processing times than the young in all but the rhyming condition where this trend was reversed. Physical processing took longer than semantic for both ages, and while rhyming was longer than orthographic for the younger subjects, the opposite occurred in the older group.

There were more cued recall intrusions by the old than the young, a difference which was larger in the physical conditions. For both ages, more free as well as cued recall intrusions occurred with physical than semantic, and rhyming than orthographic processing. Comparatively larger numbers of intrusions were given by young-rhyming-incidental and old-rhyming-intentional subgroups.

Recognition performance was better by the young than the old, although the difference was much smaller with semantic processing which was superior to physical in both ages. Rhyming produced higher area scores than orthographic in the young. For the old, rhyming was superior to orthographic with incidental instructions but inferior with intentional. There were no main effects of age in the analyses of confidence ratings or criterion ($\underline{\beta}$). However, higher criteria for the young than the old were obtained in rhyming-intentional and orthographic-incidental subgroups, while the reverse occurred in the two complementary conditions.

No clear age differences were found in analyses of organization, proportion recalled from different list sections, or RIP scores. In processing task performance, the old showed more between-subjects variability, particularly with semantic processing, but less within-subjects variability in the individual condition. They made fewer errors than the young on the orthographic task, and they reported less anxiety. A significant correlation between greater anxiety and poorer memory performance was found only in the younger group.

Retrieval Effects

One of the purposes of this study was to determine if older subjects suffer from retrieval problems which could be alleviated by retrieval cueing and recognition test procedures. At face value, the data indicate the answer to be no, since the old did not benefit more from cueing than the young, and the young still performed better in recognition. However, if these results are considered in relation to the processing tasks as well as the findings of previous studies, a different and more precise answer emerges.

On the free and cued recall, the young were superior to the old with semantic but not with physical processing, while on the recognition test, this pattern was reversed. If the recall data are converted to proportions and compared with percent correct recognition, it is apparent that the recognition test reduced the semantic age difference but increased the physical.

One possible reason for the alleviation of the semantic decrement only with recognition is that search and decision were required with the cued recall but recognition involved only decision. This analysis is based on "generation-recognition" models of recall where a cue elicits a hierarchy of associates which are then scanned for some recent context, leading to a subsequent recognition decision (Bahrick, 1969, 1970). The cue-target relationship may also be considered in terms of feature abstraction which helps to generate appropriate instances from permanent memory to be searched for recency tags (Kausler, 1974).

That older subjects face a relatively more complicated search task was suggested earlier in the introduction (Riegel, 1968; Craik, 1968; Anders & Fozard, 1973). However, there is also conflicting evidence. Drachman and Leavitt (1972) asked young and old subjects to generate in one minute as many instances as possible from given taxonomic categories and obtained no age difference. In a recent study by Eysenck (1975), the young and old did not differ in response latencies when the task involved producing a category instance beginning with a particular letter, but the old did take longer to recognize whether a word fit a certain taxonomic category. The author concluded that decision and not retrieval search was the problem the old encountered.

It is possible that for the present older subjects, the semantic cues were less unique, less strongly related to the target, or led to less feature sampling than in the young and were not as helpful in guiding the search and decision process, a difference which did not occur, however, with physical cues. This is supported by the greater occurrence of intrusions in the old, a difference which was much larger with physical than semantic processing. It may explain why Hultsch (1975) found cueing eliminated age differences only in category recall and not in items per category. The old were able to generate and decide on at least one category instance from permanent or semantic memory, but were at a disadvantage in producing the rest of the instances from recent or episodic memory. Thus, Eysenck's (1975) failure to find an age difference in retrieval latencies may be because a category plus a letter is a more unique guide or cue for the old than are single semantic cues.

The question of why the physical cues did not demonstrate an age deficit in recall but did in recognition concerns the general effects of the different processing tasks, as discussed in the following section.

<u>Levels of Processing</u>

That the older subjects were at a disadvantage in recall only at the deeper levels of processing was a major finding of this study and corroborates Eysenck's (1974) similar result with British subjects. Craik and Tulving (1975) have contended that the deeper or semantic levels lead to greater trace elaboration and retrieval facilitation than do the physical. In a similar vein, Jacoby and Goolkasian (1973) implied that access to generation and search are more direct with semantic than physical information. Using a continuous recognition procedure, Browne (1973) concluded, based on false alarm data, that the old encode fewer semantic attributes than the young. Browne's results, as well as the retrieval findings discussed above, may thus indicate less trace elaboration for the old than the young with semantic but not physical processing.

Although memory performance was worse with physical than semantic processing for both ages, the recall superiority of the young was eliminated with the former. One possible reason for this result, which has already been implied, is that physical cues and processing did not present an age-related disadvantage in retrievability. It is also possible that the old took the physical tasks more seriously than the young and consequently processed the words to a deeper level than was necessary. This notion is supported by the fewer orthographic errors and experimenter-provided rhymes in the older group. Although the interaction of age with processing and instructions fell short of significance, the group means indicated that intent to learn was more important for the young in physical than semantic tasks, while the reverse was true for the old. If intentional instructions lead to meaning processing, as was suggested by Hyde and Jenkins (1969, 1973) and Eysenck (1974), then the above analysis may be correct.

In contrast to the recall data, there was a much larger age decrement with physical than semantic processing on the recognition test. This may be due in part to the larger number of cued recall intrusions which occurred for older subjects in the physical conditions. Although the fit was not perfect, interactions obtained for this and area score data followed a pattern which suggested that intrusions were detrimental to recognition, a result previously obtained by Mandler (1972). A large number of intrusions may have required increased simultaneous processing to keep separate those items which served as cues, targets, distractors, and cued recall responses which had been guesses. As was described in the introduction, the old are at a disadvantage in such situations (Craik, 1971).

One final processing result which requires further comment is the superiority in free recall of categoric over associative processing in the young and their equivalence in the old. Some precedence for this finding occurred in the work of Denney (1974b) who has shown that the elderly are less likely to use complementary (music-piano) than similarity (king-ruler) criteria for purposes of classification. She also found that middle-aged subjects free recalled more similarity than complementary word pairs, while the reverse was true in an older group (1974a). She attributed her results to the elderly's greater isolation from educational settings claiming that complementary classifications occur more naturally in the environment while similarity groupings are a result of abstract thinking. To support her argument, she cited data in young children who also do more complementary grouping, as well as an experiment with middle-aged professionals who did less than non-professionals (1974b). Correlations between education and free recall in the present older subjects were .22 and -.08 for categoric and associative processing respectively. These were not significant, but did indicate education as a possible influence if categoric processing is considered a similarity condition and associative as complementary.

Two other results are also relevant. In the associative task, the old gave fewer category instances (similarity groupings) as their responses than did the young. In addition, the categoric versus associative interaction with age was not significant on the cued recall, and cueing advantage was greater with categoric processing for both ages. Thus, the free recall results may also be due to the greater retrieval difficulty experienced with categoric processing by the older subjects.

Task Responses

A comparison of responses given in the categoric, associative, and rhyming tasks indicated greater between-subjects variability in the older group. This confirms Riegel's (1968) similar result for free association.

In the individual condition, the older subjects showed a greater homogeneity in the type of responses they gave than did the young, although associative predominated for both. According to Battig (1975), flexibility in processing items in different ways can be facilitative in many verbal tasks. This appeared to be particularly true for the present older subjects, since for them lack of variation was associated with poorer performance. That such flexibility is an important developmental strategy is indicated in other types of psychological tasks. Using a procedure which involved extinguishing different lights with different response keys, Kay (1951) found that older subjects tended to repeat their errors more and were less flexible in changing wrong responses. Heglin's (1956) older subjects were more susceptible to induced set in a problem solving task and had greater difficulty in overcoming it than did the young. Studies of ambiguous drawings have also shown the old to be less likely to modify or alternate perceptions (Botwinick, 1973).

Additional Findings

There were several results which related in various ways to previous research and which will be briefly discussed in this section.

Intent to learn was not more important for the old than the young, which confirms Eysenck's (1974) results. In addition, the recall analyses produced no significant interactions involving instructions, although the interaction of age with processing and instructions did approach significance. In previous studies with college students, intentional instructions were more beneficial in physical than semantic tasks (Mondani et al., 1973). The failure to obtain a significant interaction here may be due to the present materials which were not conducive to organization strategies. The latter have been noted by Hyde and Jenkins (1969) to be an important consequence of intent to learn.

Most investigators of the forward digit span have found no age differences, yet in the present study, the old were significantly worse on this pretest. The difference may be due to the longer presentation rate which involved a one-second stimulus exposure plus an approximate .75 second interslide interval instead of a one digit per second rate (Drachman & Leavitt, 1972). This probably provided enough extra time for recoding of the digits, a strategy which is more difficult for the old (Taub, 1974). However, the lack of correlation between the digit span pretest and subsequent memory performance casts doubt on its use as a pre-selection device in geriatric studies.

The anagram pretest did not produce age differences, although they might have been expected since the old have often been shown to be poorer at problem solving (Botwinick, 1973). However, comments by the elderly subjects indicated a frequent use of crossword puzzles and similar letter games which may have benefitted their performance on the anagram as well as the orthographic task. It is also possible that the older subjects received a better education and training in English skills such as spelling than did the college students, a factor which would additionally modify their anagram solutions and their use of the physical cues.

Many reaction-time studies have demonstrated a slowing of response with increasing age (Botwinick, 1973). However, this effect was shown to vary with the particular task, as the present older subjects were actually faster than the young in the rhyming condition.

The reason for this is unclear, but their greater ease in generating rhymes may be related to a larger emphasis in their education on oral recitation, particularly of poetry. It does demonstrate that response slowing in the aged can be modified by task requirements. In addition, the recall and correlation data indicate that the "deeper" or semantic levels of processing do not necessarily take more time and neither does time alone determine memory performance. (See also Craik and Tulving, 1975.)

Neither the confidence rating analysis nor that of criterion ($\underline{\beta}$) produced an effect of age, although interactions were found for the various processing subgroups. However, Gordon and Clark (1974) reported that the elderly set higher response criteria in yes-no recognition than the young, and they cited a study by Craik (1969) where a similar result was obtained. Their suggestion was that task anxiety and cautiousness in responding might be related. It is thus possible that the self-paced and relaxed nature of the present investigation helped eliminate any general age differences in the measure. This is supported by the anxiety report which was less in the older group.

<u>Future Investigations</u>

A major age decrement was found with semantic processing, although semantic remained the more efficient memory technique within both age groups. If this effect is related to the older subjects' failure to encode as many semantic attributes and the decreased elaboration with semantic cues in the elderly, then training or requiring older subjects to differentiate each target word on a variety of semantic dimensions may aid them relatively more so than the young in free recall. The elderly may also be more subject to encoding specificity effects (Tulving & Thomson, 1973), since they might be more likely to encode a word in a single sense, sampling fewer of its features (Pellegrino & Salzberg, 1975). Changing the cue which was originally encoded with the word would cause the search and decision process to be particularly ineffective.

The data from the individual condition suggest that encoding variability within a list is relatively more important for the elderly than the young. Thus, training subjects to use different processing strategies or providing learning lists which involve various types of encoding may help eliminate age differences in some verbal tasks.

A few studies, previously cited in the introduction, have shown that in certain tasks, the old may be more subject to simultaneous interference (Craik, 1971). If this is true, then they may also benefit more from intratask interference which is said to lead to better retention and transfer (Battig, 1972). In addition, the idea of intrusions causing more confusion and interference in recognition for the old might be tested experimentally in a multitrial recognition test which varied the amount and kind of distractors on subsequent trials. This may indicate whether Gordon and Clark's (1974) finding of an age difference only on the second recognition test trial was actually due to "trace decay" or simply the simultaneous processing problem.

Since everyday situations usually require information to be remembered for longer periods of time than that in the present investigation, long-term studies of processing effects in the elderly may be in order. The few already done with verbal tasks have been confounded with age differences in original learning. Since recent experiments have implied little or no effect of mnemonics on delayed retention in younger subjects (Barrett, Maier, Ekstrand, & Pellegrino, 1975), similar experiments with the old may be enlightening.

Conclusions

As the experiment was designed to answer five specific questions given in the introduction, the conclusions will follow that format.

1) Semantic compared to physical processing produced superior recall and recognition in the young as well as the old. The age decrement was much larger with semantic processing in recall but with physical processing in recognition.

2) The old did not benefit more than the young

from retrieval cueing, but the recognition task helped alleviate the semantic recall deficit. This indicated a possible retrieval problem in the elderly only with semantic processing.

3) Intent to learn was beneficial mainly in free recall and did not significantly interact with age or processing.

4) Free recall with categoric processing was superior to associative only in the younger age group, while cueing advantage was better with categoric in both. Rhyming and orthographic conditions were equivalent in free recall, but rhyming produced better cued recall.

5) Older subjects showed more between-subjects variability but less within-subjects variability than the young. Performance in the individual condition where responding was free in nature did not differ from the performance of subjects who did semantic processing.

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