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INTERACTIONS BETWEEN HUMAN AGING AND MEMORY

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FINAL REPORT

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This final report represents the most recent funding period for the project entitled, "Interactions Between Human Aging and Memory." The specific goals and rationale for the research will be discussed first, followed by a description of the studies completed in this most recent grant period. Throughout the report, suggestions for future research directions are given. These recommendations for future research are currently guiding the research program here at Georgia Tech.

RATIONALE AND SPECIFIC AIMS OF RESEARCH

The basic goal of this research has been, and continues to be, a specification of age differences in memory performance. In other words, the research is aimed at identifying those particular aspects of memory performance that differentiate age groups and those that do not. This interactional approach is apparent in the research that has been reported in the past on this project, and the research to be discussed in the present report. A specification of interactions between aging and memory implies a conceptual view of the memory system that is componential, a description of memory in terms of the components that are and are not affected by age. Memory is viewed as involving both short-term and long-term processes (e.g., Waugh & Norman, 1965), and long-term memory is viewed as involving the stages of trace formation (encoding), trace retention (storage), and trace utilization (retrieval) (Melton, 1963). Further, information in memory can be episodically or semantically represented (Tulving, 1972). These distinctions have proven valuable in describing memory, and especially useful for specifying age differences in memory.

Through the course of this project, several hypotheses about the locus of age-related memory differences have been tested. These hypotheses, together with the primary findings from investigations testing them, are reported in Table I. This table summarizes conclusions from this past research and points to the major direction for future studies. This focus is on encoding, the component of memory implicated in a major way in accounting for differences seen between age groups. In other words, older subjects seem to encode information in a different fashion than younger subjects. This conclusion also has been given as the most viable

TABLE 1 SUMMARY OF HYPOTHESES TESTED AND RESULTS OBTAINED ON INTERACTIONS BETWEEN AGE AND MEMORY

HYPOTHESIS:	I. DEFICIT IN SHORT-TERM MEMORY
RESULTS:	While sensory memory duration is shorter in older age groups, differences are negligible and cannot account for differences between age groups on memory tasks (Walsh & Thompson, 1978). Also, age differences found only for those positions of serial position curves assumed to be recalled from long-term memory (Craik, 1977; Smith, 1980). Estimates of primary memory capacity seem to be unaffected by age (Craik, 1977).
CONCLUSION:	MINIMUM AGE DIFFERENCES IN SHORT-TERM MEMORY
HYPOTHESIS:	II. DEFICIT IN LONG-TERM MEMORY
	A. GREATER SUSCEPTIBILITY TO INTERFERENCE (TRACE RETENTION)
RESULTS:	When systematically examined, no age differences in susceptibility to interference (Smith, 1975a). Also, no age differences in the amount of response interference in organized recall (Smith, 1974). A replication of these results with independent samples from the same cohorts is discussed in the later progress report.
CONCLUSION:	NO EVIDENCE FOR INCREASED SUSCEPTIBILITY TO INTERFERENCE
HYPOTHESIS:	B. RETRIEVAL DEFICIT (TRACE UTILIZATION)
RESULTS:	At first, evidence seemed to support retrieval hypothesis: (1) Differences in recall, but minimum, if any, differences in recognition (Schonfield, 1965; Smith, 1975b); (2) Age differences attenuated with cued recall (Smith, 1977); (3) Differences greater with tasks requiring greater reliance on retrieval (Smith, 1980). But evidence has other interpretation: If older subjects encode information in different ways (e.g., organize less), then this difference in encoding would affect recall, cued recall, and recognition differently. Also, on tests looking at retrieval of well-learned information (e.g., semantic memory tasks, vocabulary, very-long-term memory recall), age differences are often not found (Smith & Fullerton, 1981).
CONCLUSION:	OLDER PERSONS EXPERIENCE PROBLEMS AT RETRIEVAL, BUT THIS IS PROBABLY DUE TO ENCODING DIFFERENCES
HYPOTHESIS:	C. DIFFERENTIAL ENCODING (TRACE FORMATION)
	1. DIFFERENCES IN ELABORATION
RESULTS:	Some data suggest that older persons have maximum difficulty with tasks that require semantic or elaborative processing. Other experiments suggest that induced elaborative processing minimizes age differences in recall (Craik, 1977, 1980; Burke & Light, 1981; Erber, Herman, & Botwinick, 1980; Mason, 1979; Perlmuter, 1978; Smith, 1980).
CONCLUSION:	CONTROVERSY CONCERNING NATURE OF ELABORATIVE PROCESSING DEFICIT -- EXPERIMENT PROPOSED TO EXAMINE POSSIBLE RESOLUTION TO CONFLICTING DATA
HYPOTHESIS:	2. DIFFERENCES IN IMAGERY
RESULTS:	There are mixed results for the imagery-deficit hypothesis. Older persons do worse with imagery instructions (Mason & Smith, 1977) and take much longer to perform mental rotations (Cerella, Poon, & Fozard, 1981). But differences are reduced with imagery orienting tasks (this progress report) and the magnitude of the picture superiority effect does not vary with age (Winograd, Simon, & Smith, 1982). There is no interaction between age and concreteness (Smith & Mason, 1977) while older persons do worse with visual mediators.
CONCLUSION:	CONTROVERSY CONCERNING IMAGERY DEFICIT -- EXPERIMENTS ARE PROPOSED TO DIFFERENTIATE BETWEEN IMAGERY AS A SEMANTIC FEATURE AND IMAGERY AS A CONTROL PROCESS, AND TO SYSTEMATICALLY STUDY IMAGERY ENCODING AS FOR MNEMONIC EFFECTIVENESS
HYPOTHESIS:	3. DIFFERENCES IN ORGANIZATIONAL PROCESSING
RESULTS:	Clear evidence for less organization in older age groups: (a) Lower measures of organization, both clustering and subjective organization (Smith, 1980); (b) Recall improved with organization instructions or with recognition (Hultsch, 1971, 1974; Smith, 1980, Later progress report); (c) The probability of recall differences between age groups is smaller with longer lists reflecting organizational differences (Smith, 1979). While evidence clearly supports a quantitative deficit, there are suggestive data for qualitative differences as well (Smith, 1980; Later progress report).
CONCLUSION:	CLEAR EVIDENCE FOR LESS ORGANIZATION PROCESSING IN OLDER AGE GROUPS -- EXPERIMENTS ARE PROPOSED TO EXAMINE QUALITATIVE NATURE OF ORGANIZATIONAL PROCESSING AS A FUNCTION OF AGE

hypothesis for the poor performance of older subjects on memory tasks by other recent reviewers of the field (Baltes, Reese, & Lipsitt, 1980; Burke & Light, 1981; Craik, 1977; Hartley, Harker, & Walsh, 1981; Hultsch & Deutsch, 1981; Poon, 1983, in press; Smith, 1980; Smith & Fullerton, 1981).

Three different types of encoding are to be discussed in this report: (1) ELABORATION, the richness of encoding for each individual item during acquisition; (2) ORGANIZATION, the degree to which the different items are related to each other during acquisition; and (3) VISUAL IMAGERY, encoding based on visual rather than verbal features. Studies examining these three different types of encoding as a function of age are reported in the progress report and additional experiments are proposed in the Methods of Procedure section.

Elaboration. The typical way to study elaborative processing is to give subjects different orienting tasks to perform during presentation of the material and then to test memory following processing controlled by the tasks (e.g., Craik & Tuvling, 1975). It is assumed that semantic orienting tasks control elaborative processing and produce more durable memories for the material (e.g., Cermak & Craik, 1979). Eysenck (1974) found support for the hypothesis that the level of elaboration reached by older subjects is less than that reached by young subjects. Different age groups were given different orienting tasks to perform (structural or semantic), after which they were tested by free recall. Eysenck observed greater age differences when the orienting task involved elaborative processing. It seems, therefore, that the older group was especially disadvantaged when elaborative or semantic processing was required. In other experiments using procedures similar to Eysenck's, White (as reported by Craik, 1977), Perlmuter (1978), and Craik and Simon (1980) used recognition in addition to recall and found reduced age differences with the elaborative task. However, Mason (1979), in an experiment conducted on this project, and Erber, Herman, and Botwinick (1980) found differences with the semantic task, supporting Eysenck's original finding. The question remains as to whether elaborative tasks increase or decrease the age differences seen with no task, i.e., differences found under standard learning conditions. One possible variable in these studies, in addition to several other procedural differences, is the qualitative nature of the semantic task. There is probably no single structural-semantic dimension (Postman, 1975), and so the nature of elaborative processing can be dependent on other confounded dimensions. For example, Craik and his colleagues have suggested that older adults are especially disadvantaged when episodic, context-specific processing is required (Craik, 1981; Craik & Rabinowitz,

1982). Young and old differences are greatest in such conditions. When general semantic encoding of the material is required unrelated to the episodic context of the presentation, then age differences are minimized. In other words, older adults rely more on general, conceptual encoding and less on specific, episodic processing. "Semantic tasks" have been used that encourage both types of elaborative encoding. A specific encoding task would be to place the item into a sentence frame and a general semantic encoding would be to rate the pleasantness of the word (used in the studies reported later that reduce age differences). This hypothesis also suggests that the elderly would be less susceptible to encoding specificity (Smith, 1981).

Organization. It is clear that older subjects organize less than younger subjects (Hultsch, 1971, 1974; Smith, 1980). In addition, age differences are reduced on tasks designed to induce organizational encoding. The research on organizational processing in different age groups has thus far dealt only with quantitative measures of organization, measures of the amount of grouping without looking at the nature of the groupings used by different age groups. Recently, there have been attempts to look at the quality of organization in the memory literature (e.g., Friendly, 1980), and these advances will be applied to age differences in organization. Several different lines of research suggest that this is a fruitful approach. The free association literature suggests that not only do older subjects give fewer associations, but they also give different types of associations in a free association task (Riegel, 1968). There is also evidence that suggests that information presented in a story is less susceptible to age effects than information presented in discrete lists (Dixon, Hultsch, & Simon, 1982; Meyer, 1981).

Imagery. As seen in Table 1, some experiments show imagery deficits in older subjects, e.g., speed of mental rotation (Cerella, Poon, & Fozard, 1981), and imagery instructions (Hulicka & Grossman, 1967; Mason & Smith, 1977). However, other experiments find no such effects, e.g., concreteness effects (Mason & Smith, 1977), and picture-superiority effects (Winograd, Smith, & Simon, 1982). In an experiment to be reported later, an imagery orienting task actually reduced age differences in memory performance, a result similar to some mnemonic studies in the literature (e.g., Robertson-Tchabo, Hausman, & Arenberg, 1976). These apparently conflicting findings may be clarified by using the distinction Baddeley (1980) makes between imagery as an encoding process and imagery as a feature of the to-be-remembered item. The former seems to be affected by age and the latter does

All three encoding strategies were examined in the first experiment by using the orienting task procedure. Subjects were given general instructions about the nature of the experiment, and then were given instructions about the nature of the particular orienting task they were to perform during the presentation of the list. A list of 24 items was then presented at an 8-sec rate. The words were visually presented on a screen and simultaneously auditorially presented by a tape recording. All subjects were presented the same list of words (English nouns equated for frequency) and were given 3 min. for free recall at the time of test. Four encoding conditions were used. One group was told to image each word and to rate the vividness of the image on a three point scale (IMAGERY). A second group was told to place each word into one of three taxonomic categories, animals, trees, or occupations (ORGANIZATION). A third group rated each word on a 3-point scale of pleasantness (ELABORATION). The fourth group was told to study the words but were not given a specific task to perform during the presentation of the items (STANDARD). The results of the experiment are presented in Table 3. For both the

TABLE 3 MEMORY PERFORMANCE IN THREE ADULT AGE GROUPS AFTER PERFORMING VARIOUS ORIENTING TASKS (STANDARD = NO TASK; ORGANIZATION = CATEGORIZATION TASK; ELABORATION = PLEASANTNESS RATING TASK; IMAGERY = IMAGERY VIVIDNESS RATING TASK)

AGE GROUP	ORIENTING TASK CONDITION			
	STANDARD	ORGANIZATION	ELABORATION	IMAGERY
YOUNG (20-39)	14.80	14.96	14.55	15.26
MIDDLE (40-59)	11.94	12.94	14.15	13.80
OLD (60-80)	8.18	9.52	10.44	10.78
OLD/YOUNG	55%	63%	72%	71%

young and the middle aged groups, there were no differences between any of the encoding conditions. For the oldest group, however, mnemonic effects were found. Free recall of the list was facilitated by both the imagery task and the elaboration task ($p < .05$). Performance in the oldest group was better after these encoding conditions than after standard instructions, thus supporting an hypothesis which suggests that the processing deficit seen under standard memory conditions can be reduced by tasks that induce particular encoding. In other words, while older subjects spontaneously do not use these encoding strategies like the younger subjects, performance can be modified by experimental conditions. An unexpected finding, however, was that the organizational task did not facilitate performance in the oldest subjects. Previous research from this laboratory (see Table 1) and other laboratories has shown that the organizational deficit is one of the more

robust differences between adult age groups, and furthermore, that compensation through organizational instructions is possible (e.g., Hultsch, 1969, 1971). Reasons for this failure to produce mnemonic facilitation with the organization orienting task were examined in the next two experiments. These experiments were based on the assumption that the orienting task as used in the previous experiment may be inadequate to control organizational encoding. With only one presentation of the words, and the simple nature of the response required by the orienting task, sufficient organizational processing to reduce observed age differences with standard instructions may not have been achieved.

In the first of these two experiments, the orienting task was used as in the first experiment, but three learning trials were given instead of one to increase the possibility for organizational processing. In addition to the change to three trials, two other differences were made in the procedure: (a) only three encoding conditions were used (imagery, organization, and standard); and (b) only the oldest group was used (aged 60-80). The results of this experiment are presented in Figure 1. On the first trial, the results of the earlier experiment were replicated.

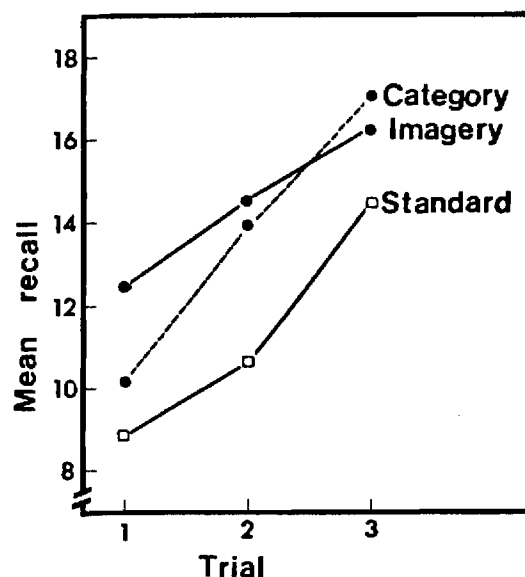


FIGURE 1 MEAN NUMBER OF WORDS RECALLED ON THREE TRIALS WHEN USING EITHER AN ORGANIZATION, ELABORATION, OR NO ORIENTING TASK. THESE DATA REPRESENT AN OLDER GROUP OF SUBJECTS (60-80 YEARS).

The imagery task did produce higher levels of recall than either the standard instructions or the organizational task. On successive trials, however, the organizational task facilitated recall performance to the same extent as did the imagery task ($p_s < .05$). These results indicated that for the different types of processing investigated in this research, older subjects show deficits. In other words, in

standard learning conditions, older subjects spontaneously organize and image less than younger subjects. The results also indicate that when the conditions are arranged to promote a particular type of encoding, either through experimental intervention or by instructions, older subjects can perform these operations. While not obtaining the high levels of performance seen in younger subjects, the age differences are significantly reduced by such conditions.

In the next experiment, organizational processing was manipulated in a different way from the orienting task. The individuals in this experiment were instructed in the use of organizational processing and told that grouping the words into categories would help them at the time of test. In addition, to induce organization, the words from each category appeared one after the other, i.e., they were blocked during presentation. The standard condition was as in the previous two experiments with the words randomized during presentation, and with no specific instructions given. In addition to the conditions of encoding, the conditions of retrieval were also manipulated in this experiment. Half of the subjects were tested by free recall and the other half were tested by recognition. Conditions of encoding (Organization or Standard) and conditions of retrieval (Recall or Recognition) were factorially combined as between-subject variables. The words were presented at a 5-sec rate and 3 min were given for recall. The recognition test consisted of a forced choice between a word which had been presented in the list and another word chosen from the same category. The results of this experiment are presented in Table 4. The often cited finding of age differences in free recall after stan-

TABLE 4 RECALL AND RECOGNITION PERFORMANCE AS A FUNCTION OF AGE, ENCODING CONDITION, AND RETRIEVAL CONDITION

AGE GROUP	STANDARD	ORGANIZATION	PERCENT CHANGE
<u>FREE RECALL</u>			
YOUNG (20-49) <i>n</i> =20	23.6	27.9	18%
OLD (50-80) <i>n</i> =20	16.1	22.7	41%
OLD/YOUNG	63%	82%	
<u>RECOGNITION</u>			
YOUNG (20-49) <i>n</i> =20	46.2	44.9	-3%
OLD (50-80) <i>n</i> =20	42.1	42.9	2%
OLD/YOUNG	91%	96%	

ard instructions was replicated, but the magnitude of this effect was greatly reduced either by organizational encoding or by the use of recognition at the time of test. In addition as predicted, organizational processing benefited recall

performance, but not recognition. There are obvious problems, however, with possible ceiling effects in the recognition data. More importantly, the older group showed a 41% improvement in recall with organization, while the younger adults, who are assumed to use organization spontaneously, improved by only 18%. This finding supports the earlier experiment which showed that older adults can organize if the proper conditions are arranged, even though they do not tend to organize spontaneously as much as younger subjects. Taken together, these studies support a view of memory aging which attributes a significant proportion of the difference between adult age groups to processing strategy, differences that can be reduced or supported by instruction or by experimental intervention. This plasticity in memory performance is important because it suggests that not all memory difference can be attributed to some irreversible deterioration. These results also can explain why age differences in recognition memory are smaller than age differences in recall. The reason that is most often given for the interaction between age and type of test is that older subjects have a retrieval deficit, a deficit that is tapped by recall but not recognition. The assumption behind this conclusion is that recognition is insensitive to retrieval differences, and thus, insensitive to age differences. The present research attaches an important qualification to this explanation. Recognition is less sensitive to retrieval because it is less sensitive to organizational processing at encoding. Organizational processing is an optimal strategy for recall where retrieval is benefited from having the list items grouped together, but not for recognition where retrieval of the items is not a major requirement of the task. If older adults organize less as this research suggests, then the strategic difference between age groups should be reflected in recall, but not in recognition which is relatively insensitive to organizational differences. These studies additionally suggest that the "processing deficit" must rely on several different qualitative encoding dimensions rather than a single quantitative dimension. It is not sufficient to say that older persons process less, but the qualitative type of processing must be specified. Future research should begin to focus on the qualitative nature of processing as a function of adult age. For example, studies are needed to study the qualitative nature of organizational processing in different age groups. We now know that older subjects organize less, but does this finding reflect the fact that older subjects are organizing differently?

In Table 3, there is also evidence for a reduction in imaginal coding by older adults under standard learning conditions. Several studies also have been conducted to examine further this type of processing in older subjects. Two

different experimental approaches were used, just as with the organizational studies. First the degree of visual processing was measured directly by using visual clustering as a dependent variable. If older subjects rely less on visual coding, then the degree of visual clustering should be less than in younger subjects. In addition, visual coding was studied by using the "picture-superiority effect," the fact that pictures of items are remembered better than the words representing those items. The explanation of this phenomenon is that a picture allows visual as well as verbal (semantic) coding of the item, and this dual coding facilitates later recall (Pavio & Csapo, 1973).

The first series of four experiments dealt with imaginal coding by directly measuring both semantic and visual clustering in the recall protocols of subjects. Frost (1971, 1972) has done this with young subjects and found that subjects can use both encoding dimensions, even though the degree of semantic clustering is greater than visual clustering. The first experiment of this series was an attempted replication of this finding in groups differing in adult age. Different aged subjects were presented the Frost line drawings (see Figure 2) which could either be grouped







Experiment 1	Experiments 2 and 3
 VISUAL: SLANTED LEFT SEMANTIC: ARTICLE OF CLOTHING	 VISUAL: RED SEMANTIC: OCCUPATION
 VISUAL: SLANTED LEFT SEMANTIC: FURNITURE	 VISUAL: RED SEMANTIC: BUILDING
 VISUAL: HORIZONTAL SEMANTIC: ARTICLE OF CLOTHING	 VISUAL: BROWN SEMANTIC: BUILDING

FIGURE 2 EXAMPLES OF MATERIALS USED IN THREE EXPERIMENTS EXAMINING SEMANTIC AND VISUAL CLUSTERING.

visually or semantically. Four different taxonomic categories were used (i.e., vehicles, animals, articles of clothing, and pieces of furniture) and four different

visual categories (i.e., slanted left, slanted right, horizontal, vertical). There was overlap among the dimensions so that independent measures of semantic and visual clustering could be obtained. In other words, for each category, three different orientations were represented by four different category items. This was the procedure used by Frost. In all, 16 different items were presented to each subject. Across subjects, each category item appeared equally often in each visual orientation. The results of this experiment are presented in Table 5. As would be expected

TABLE 5 COMPARISON OF VISUAL AND SEMANTIC CLUSTERING UNDER DIFFERENT TASK CONDITIONS (EXPERIMENTS I AND II), INSTRUCTIONS (EXP. III), AND PRESENTATION RATE (IV)

EXPERIMENT DEPENDENT MEASURE	AGE GROUP	
	YOUNG	OLD
EXPERIMENT I (slant vs. category)		
NUMBER OF WORDS RECALLED (from 16)	10.32	8.02
SEMANTIC CLUSTERING DIFFERENCE SCORE	.09	.03
VISUAL CLUSTERING DIFFERENCE SCORE	.01	-.02
EXPERIMENT II (color vs. category)		
NUMBER OF WORDS RECALLED (from 32)	17.80	10.15
SEMANTIC CLUSTERING DIFFERENCE SCORE	.40	-.07
VISUAL CLUSTERING DIFFERENCE SCORE	-.06	-.09
EXPERIMENT III (color vs. category)		
CONTROL CONDITION		
NUMBER OF WORDS RECALLED (from 32)	21.70	11.79
SEMANTIC CLUSTERING DIFFERENCE SCORE	.41	.18
VISUAL CLUSTERING DIFFERENCE SCORE	-.08	-.11
VISUAL INSTRUCTIONS		
NUMBER OF WORDS RECALLED (from 32)	17.00	11.00
SEMANTIC CLUSTERING DIFFERENCE SCORE	.14	.19
VISUAL CLUSTERING DIFFERENCE SCORE	.12	-.05
SEMANTIC INSTRUCTIONS		
NUMBER OF WORDS RECALLED (from 32)	20.83	13.57
SEMANTIC CLUSTERING DIFFERENCE SCORE	.50	.25
VISUAL CLUSTERING DIFFERENCE SCORE	-.04	-.08
EXPERIMENT IV (Young only: fast vs. slow presentation rate)		
FAST PRESENTATION RATE (1.5 sec)		
NUMBER OF WORDS RECALLED	9.85	
SEMANTIC CLUSTERING DIFFERENCE SCORE	.26	
VISUAL CLUSTERING DIFFERENCE SCORE	.25	
SLOW PRESENTATION RATE (5 sec)		
NUMBER OF WORDS RECALLED	14.39	
SEMANTIC CLUSTERING DIFFERENCE SCORE	.42	
VISUAL CLUSTERING DIFFERENCE SCORE	.14	

from past research, there was greater semantic clustering in the young group than in the old group, even though the amount of clustering was very low. Neither group, however, spontaneously clustered using the visual (slant) dimension. The interaction between type of clustering and age was significant ($p < .05$). Even with a large number of subjects, Frost's results of visual clustering could not be obtained. Unfortunately, if there is no visual clustering in the young group, it is impossible to assess differential effects due to age.

The second experiment in this series sought to determine if a more salient visual cue (color) would be more helpful in spontaneous organization. Another

advantage of the color visual cue is that color is an integral part of the stimulus item, unlike visual orientation. In other words, orientation as a visual cue is dependent on the episodic presentation context. The same design was used in this experiment except that the number of words was increased to 36 and the counterbalancing between item and visual cue could not be obtained because the color of the object was integrated as part of each stimulus item. Example materials are shown in Figure 2. As can be seen in Table 5, semantic clustering was increased in the younger group, and the difference between the age groups on semantic clustering was actually larger than in the earlier experiment. However, as with the first experiment, neither group used the visual dimension for clustering. One possibility for these results is that the saliency of the semantic dimension (taxonomic categories) reduces the chance of finding visual clustering. Because visual clustering was not used spontaneously in either age group, a third experiment was conducted to determine if such organization by color would occur if appropriate instructions were given. In a between-groups design, subjects were asked to attend either to semantic (category) or visual (color) dimensions and to use these cues to help remember the words. A third group was told to "study carefully" the items without specific instructions (control). The results of this experiment are also presented in Table 5. In the young group, significant semantic clustering was observed with both the semantic instructions and control conditions. In the visual-instructions condition, there was a significant reduction in the amount of semantic clustering accompanied by a significant increase in visual clustering. In other words, the younger group visually clustered only when given specific instructions to do so. The older subjects semantically clustered to a lesser degree than the younger ones in both the semantic instructions and control conditions. Again, as in the earlier organization studies, the older subjects organized when instructed to do so, but only when the cue was semantic in nature. It is interesting to note that when the younger subjects visually clustered, recall performance was significantly reduced. These studies showed that visual imagery is not a good cue for organizational encoding, despite the earlier results reported by Frost. While semantic clustering is correlated with improved recall, this is not the case with visual clustering. In fact, visual clustering in these experiments was detrimental to recall.

In these three studies, younger subjects never spontaneously organized along visual dimensions as was done in Frost's experiments. There were several differences between the procedures used here and those used by Frost, none of which

should have made a difference, assuming the theoretical explanation given by Frost for the phenomenon of visual clustering. For instance, a slower presentation rate was used to make sure older adults had enough time to process the information (Birren, Woods, & Williams, 1980). It was discovered later that speed of presentation may have an effect on the way pictures are processed (Nelson, Reed, & Walling, 1976), so a fourth experiment was conducted with young subjects only to determine if speed of presentation could influence visual clustering, specifically. It was found that a fast presentation rate decreased semantic clustering while increasing visual clustering.

A second series of experiments examined visual encoding as an elaborative aid, i.e., an improvement of the encoding of each item, item qua item, rather than an aid in relating the items together. In these experiments, memory for pictures and words was compared in young and old adults. If visual encoding declines faster than verbal encoding with age, then the recall advantage of pictures over words should be smaller in the older age group. The usual explanation of the picture-superiority effect in young subjects is that when presented with a picture, one is more likely to store both a visual and verbal (name) representation than when presented with just its name. Earlier, Winograd and Simon (1980) reported the results of such an experiment. These results indicated that while the typical picture-superiority effect was found for young subjects, no advantage of the pictures was seen in older subjects. Combined with the results of the earlier reported experiments in this report on visual clustering, this would suggest that older subjects have problems in using imaginal encoding. There are problems, however, with the Winograd and Simon study. First, the magnitude of the picture-superiority effect was quite small even in young subjects. Second, another explanation of the results, not relying on visual encoding, is possible. Pictures are visually encoded, but they also encourage more distinctive verbal encodings of the items (Craik & Simon, 1980).

In an experiment to be reported here, pictures and words were again compared in different age groups, but with another condition to distinguish between visual coding and semantic elaboration. Half of the subjects in each age group performed a semantic orienting task while looking at the items. The orienting task was used to control for semantic processing. The task was to indicate for what use each item could be put (to indicate a function for each item). The other condition represented a replication of the Winograd and Simon study. The results of this experiment are presented in Table 6. While the young adults recalled more items

than did the older adults, the interaction found by Winograd and Simon was not replicated in this experiment. In other words, the picture-superiority effect was

TABLE 6 THE PICTURE SUPERIORITY EFFECT AS A FUNCTION OF ADULT AGE IN VARIOUS CONDITIONS

AGE GROUP	PICTURES	WORDS	PICTURE SUPERIORITY EFFECT
<u>WINOGRAD AND SIMON (1980) - SUBJECTS NAME OBJECTS WHEN PRESENTED</u>			
YOUNG (18-22) $n=22$	13.5	11.8	+1.7
OLD (60-85) $n=21$	9.0	9.2	-.2
OLD/YOUNG	67%	78%	
<u>SUBJECTS NAME OBJECTS WHEN PRESENTED (STANDARD)</u>			
YOUNG (18-23) $n=49$	13.2	12.3	+ .9
OLD (60-80) $n=38$	8.5	7.2	+1.3
OLD/YOUNG	64%	58%	
<u>SUBJECTS NAME OBJECTS AND INDICATE USE (SEMANTIC)</u>			
YOUNG (18-23) $n=49$	13.2	11.9	+1.3
OLD (60-80) $n=38$	8.2	7.6	+ .6
OLD/YOUNG	62%	64%	
<u>LIST LENGTH INCREASED TO INCREASE SENSITIVITY</u>			
YOUNG (18-23) $n=56$	26.5	21.9	+4.6
OLD (60-80) $n=28$	18.4	13.8	+4.6
OLD/YOUNG	69%	63%	

not different in the different age groups; the advantage of having pictures was the same in both age groups. In addition, the semantic orienting task did not change the nature of the results. A problem with these results, and the results of the original Winograd and Simon study (data presented in Table 6), is that the effect, while significant, is quite small. In fact, the largest advantage has been less than two items. Because the picture-superiority effect is so small, the sensitivity of the effect to moderation by the age variable is limited.

Another experiment was conducted to increase the experimental sensitivity by arranging conditions to enhance picture superiority in the younger adults. This was accomplished by using a much longer list (54 items rather than 24). The only other different between this experiment and the earlier one was that the picture-word variable was manipulated between-subjects rather than within-subjects. In the earlier experiment, each subject had seen two lists, one picture and one word, with the order of the lists and the order of the conditions counterbalanced. In the present experiment, separate groups were then given picture and word lists. The results of this experiment are also presented in Table 6. As can be seen, the picture superiority effect was indeed larger in this experiment. However, unlike the original Winograd and Simon results, there was no interaction between the effect and the age variable. To summarize, three studies have compared picture

and word recall in young and old subjects and the evidence suggests that older persons benefit to the same extent, neither more nor less, than younger persons from pictorial depiction. So, while there seems to be evidence to suggest that older subjects do not use imaginal encoding as much as older subjects, there is also evidence, as in the present experiments, to suggest that they can use the visual features to facilitate recall. The failure of the semantic orienting task to change the effect argues against an interpretation of these results based solely on semantic encoding. The picture-superiority effect is the same in different age groups (Table 6), and an imagery orienting task can reduce the age differences normally seen in standard free recall (Table 3).

One conclusion of this research is that age interacts with imagery only when it involves spatial processing of the material. For example, instructions to use imagery, or tasks requiring manipulating imagerys, can attenuate or amplify age differences in memory tasks, such as in the first experiment in the progress report where an imagery orienting task reduces age differences. When the imaginal nature of the material is being manipulated, however, such as when pictures are compared with words or concrete with abstract words, age differences are constant across these manipulations. Baddeley (1980) has suggested that manipulating the imaginal nature of the material is different from spatial processing. Such a distinction seems to gain validity when looking at age differences with different imagery tasks.

Collectively, the research conducted during this phase of this research project leads to several conclusions, and to several directions for future research.

CONCLUSIONS:

- (1) The largest age differences in memory are produced when subjects have to rely on their own mnemonic devices. This is evidenced by the differences seen in standard conditions without instructions or mnemonic intervention.
- (2) This lack of spontaneous mnemonic processing can be attenuated by experimental intervention. Evidence suggests that older subjects can process information in a strategic fashion if the experimental conditions are arranged to induce these types of processing. When this occurs, memory performance of the older subjects is improved and age differences are reduced. This plasticity in memory performance suggests that age difference in memory performance can be described in part by strategic changes

as a function of age rather than irreversible deficits.

- (3) These strategic changes involve more than one type of processing. Qualitatively different types of processing have been implicated.
- (a) ORGANIZATION - The evidence is clear that age groups differ in the amount of spontaneous organization. Previous research has focused on quantitative differences in measured organization and the effects of these organizational differences on recall and recognition performance. Future research should focus on differences in the types of organization used by different age groups, qualitative differences rather than quantitative differences.
 - (b) IMAGERY - Like organization, there also seem to be differences in the use of visual imagery as a function of age. However, evidence for differences in visual imagery are dependent on the procedure used to assess imaginal processing. Some paradigms show no age effects (e.g., concreteness, picture-superiority) while some show imagery differences (e.g., imagery instructions, visual clustering). Experiments are needed that clarify the nature of these different findings especially if imagery encoding is to be used for mnemonic effects in older subjects.
 - (c) ELABORATION - The results from the present project suggest that older subjects engage in less spontaneous elaborative processing, but that when the conditions are arranged to induce this processing, age differences are reduced. Other research shows different effects; when conditions are present to induce semantic encoding, age differences are larger. An experiment is proposed to suggest that there are qualitative differences in the nature of semantic encoding, and that these differences may account for the different results obtained by different investigators.

LONGITUDINAL STUDY OF MEMORY

It is realized that because the research being conducted in this project is cross-sectional in nature, age differences are being examined rather than age changes. While clarification of age differences in memory performance is a worth-

while research endeavor, the separation of age, cohort, and time of measurement would provide better understanding of the relationship between age and memory. In 1982, eight years after the original experiment was conducted, a replication of the Smith (1975a) experiment is being conducted. This study examines differential effects of interference across age and uses independent samples from the same cohorts used in 1973-74. By using the paired-associate probe technique (Tulving & Arbuckle, 1966), input and output positions of individual item pairs are factorially combined. Therefore, the retention interval and the activity contained in the retention interval is precisely controlled. The data replicate the earlier finding that aging does not entail an increased susceptibility to interference, even though there is a decline in associative memory performance with age that is attributable to changes in long term memory (early input positions and late output positions). Time-sequential and cross-sequential analyses suggest that there were no environmental influences between times of measurement that can account for changes in associative memory. In other words, the measurements were stable across the eight-year span between times of measurement. Overall, age and cohort were both significant effects in the time-sequential and cross-sequential designs respectively. The overall recall results for the two times of measurement are plotted in Figure 3. While definitive conclusions will have to await a third time

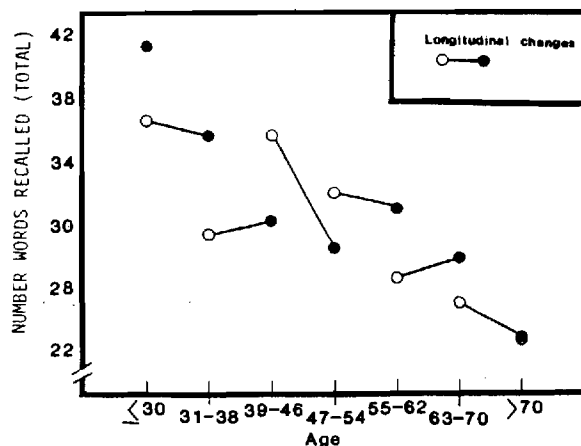


FIGURE 3. Within-cohort age changes for overall recall performance in paired-associate probe experiment

of measurement for a cohort-sequential analysis, these tentative results suggest that cohort may be an important factor in the decline in associative memory typically seen between age groups.

Smith, Anderson D.

PERIOD COVERED BY THIS PROGRESS REPORT:

The period covered by this report is August 1, 1980 to March 30, 1983.

PROFESSIONAL PERSONNEL:

The principal investigator of this project since its inception has been Dr. Anderson D. Smith, Professor of Psychology. He devoted one-quarter time during the academic year (three quarters) and full time during the summer quarter. Assistants on this project have included: Dr. Audrey Fullerton, Dr. Elizabeth Stine, Ms. Angie Benham, Dr. Rhea Eskew, and Ms. Patricia Tun.

PUBLICATIONS: (not reported in previous project report and completed in current grant period)

Smith, A.D. Age differences in encoding, storage, and retrieval. In L. W. Poon, J. L. Fozard, L. Cermak, D. Arenberg, & L. Thompson (Eds.), New Directions in Memory and Aging: Proceedings of the George A. Talland Memorial Conference. Hillsdale, N.J.: Lawrence Erlbaum Associates, 1980.

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Smith, A.D. New directions in the cognitive psychology of aging. In L. W. Poon (Ed.), Aging in the 1980's: Psychological Issues. Washington, D.C.: American Psychological Association, 1980.

Fullerton, A.M., & Smith, A.D. Age related differences in the use of redundancy. Journal of Gerontology, 1980, 35, 729-735.

Winograd, E., Smith, A.D., & Simon, E. Aging and the picture superiority effect in recall. Journal of Gerontology, 1982, 37, 70-75.

Smith, A. D. Adult age differences in cognitive function. Invited address to the Human Factors Society. Proceedings of the Human Factors Society, 1982, in press.

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CHECKLIST

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TYPE OF APPLICATION:

- ☐ NEW application (This application is being submitted to the PHS for the first time.)
- ☐ COMPETING CONTINUATION of grant number: _____
(This application is to extend a grant beyond its original project period.)
- ☐ SUPPLEMENT to grant number: _____
(This application is for additional funds during a funded project period.)
- ☒ REVISION of application number: AG00445 - 08
(This application replaces a prior version of a new, competing continuation or supplemental application.)
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Name of former Principal Investigator/Program Director: _____

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Indicate the applicant organization's most recent indirect cost rate established with the appropriate DHHS Regional Office. If the applicant organization is in the process of initially developing or renegotiating a rate, or has established a rate with another Federal agency, it should, immediately upon notification that an award will be made, develop a tentative indirect cost rate proposal based on its most recently completed fiscal year in accordance with the principles set forth in the pertinent *DHHS Guide for Establishing Indirect Cost Rates*, and submit it to the appropriate DHHS Regional Office. Indirect costs will not be paid on foreign grants, construction grants, and grants to individuals, and usually not on grants in support of conferences.

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Is this an off-site or other special rate, or is more than one rate involved? ☐ YES ☐ NO
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- ☒ No DHHS Agreement, but rate established with ONR, Arlington, VA Date 4-28-81
- ☐ No Indirect Costs Requested.