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Aging, Cognitive Abilities, and Word Frequency as Factors Affecting the Speed of Lexical Access

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AGING, COGNITIVE ABILITIES, AND WORD FREQUENCY AS FACTORS AFFECTING THE SPEED OF LEXICAL ACCESS

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This Dissertation submitted by Robert A. Laidlaw in partial fulfillment of the requirements for the Degree of Doctor of Philosophy from the University of North Dakota has been read by the Faculty Advisory Committee under whom the work has been done, and is hereby approved.

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This Dissertation meets the standards for appearance and conforms to the style and format requirements of the Graduate School of the University of North Dakota, and is hereby approved.

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ABSTRACT

The present study evaluated the impact of age and several individual difference measures on lexical access. Additionally, eight different levels of frequency were evaluated for the stimulus words. These frequency levels were derived from the frequency of usage of these words in common reading materials. The response measured was latency of reading words out loud as they appeared on a screen. The results indicated no difference between older and younger adults on measures of anxiety, depression, or overall health. The older adults scored higher on a measure of vocabulary skills, while the younger adults scored higher on tasks involving abstract reasoning and perceptual motor problem solving.

The main finding was that younger adults were significantly faster in their latency of response to words at all levels of frequency. Both the younger and older adult groups demonstrated a pattern of quicker responding to high-frequency words and a gradual increase in response time as the level of frequency was lower. The age x frequency interaction was significant statistically but not meaningful to interpretation. The data suggest a similar response pattern for both age groups according to word frequency variable, although the younger subjects consistently responded with shorter response latencies. However, further analysis of the data suggests that a significant slowing with age or naming time independent of

age slowing in peripheral responses. The present results would be consistent with a theory of overall slowing of cognitive operations in older adults.

CHAPTER I

INTRODUCTION

The process of human aging has become a popular topic for both the general public and for scientific research purposes. There appear to be definite changes in an individual that are associated with the aging process. These can be biological changes with age (Botwinick, 1984) and can also involve a number of changes in cognitive abilities (Salthouse, 1982). The area of interest here will be to focus specifically on memory skill deterioration as a function of aging. The present review will focus on several broad categories of memory research in an attempt to build the rationale for the present study.

The first area of research reviewed will describe experiments that presented lists of words or short passages to young and old adults, and then tested retention. The studies that looked at recall of word lists examined age differences in recall versus recognition performance and compared serial position effects in young and older adults. The studies that used prose materials examined age differences in the ability to favor the main ideas in recall relative to the non-essential details.

The review of research on age deficits in memory for word lists and prose material is followed by a discussion of two theoretical explanations of these deficits: the diminished capacity hypothesis and the cognitive slowing hypothesis. A review of studies that examined the support for the cognitive slowing hypothesis is then presented.

Finally, studies will be presented that examined variations in the speed of cognitive operations as a function of the verbal ability of young adult subjects. Previous studies of adult aging suggest that the verbal ability of the subject may modulate the size of age differences observed. Therefore, tests of the validity of the cognitive slowing hypothesis may necessitate a consideration of the verbal ability of the subject.

The final section of the introduction presents the purpose of the present study and outlines the critical variables that were examined.

Recall vs. Recognition

Early approaches examined memory as a three-stage process involving encoding, storage, and retrieval and early investigations of aging and memory sought to examine if age differences were due to differences in any one or all three of these stages of memory. In order to manipulate the conditions influencing the ease of retrieval, Schonfield and Robertson (1966) compared adult age differences in performance on a recall task with performance on a recognition task. Their premise was that the recognition task would place minimal retrieval demands on the subject while a recall task would place maximum retrieval demands. They used subjects between

20 and 75 years of age and divided them into four groups of each decade between 20 and 60 with a fifth group comprised of those over 60 years of age. Their task involved the presentation of a list of 24 words with each word presented for 4 seconds. Each list consisted of 8 high, 8 medium, and 8 low-frequency words. The frequency of the words was defined by an analysis of their usage in common literature (Kucera & Francis, 1967). Immediately after presentation, the subject was tested either through recall or recognition for memory of the word list. Recall involved merely saying as many words from the list as the individual could remember, in any order. Recognition involved choosing each target word from a list consisting of five choices. Their results demonstrated no significant difference between age groups on recognition scores but a steady decline with age on recall scores. Schonfield and Robertson (1966) assumed that any difficulties due to encoding would be evident on both the recognition and recall scores and therefore their findings suggest that the memory deficits associated with aging are due to the factors operating during the process of retrieval.

Following the work of Schonfield and Robertson (1966), two points of view emerged regarding interpreting comparisons of recall and recognition data. One theoretical approach suggested that recall involved both storage and retrieval of information in memory, while recognition only involves storage with no requirement of retrieval processes. A second group felt that a recognition task does reflect some retrieval processes and therefore recall and recognition are not distinct and separate processes (Erber, 1974).

Erber (1974) undertook research to further investigate the recognition and recall abilities of old and young populations. She felt that the inability to observe decreased performance with age in previous recognition tasks was due to the lower level of difficulty of recognition in comparison to recall. In her study, she presented subjects with lists of both 24 and 60 words with the words presented for four seconds each. The words used included only high-frequency words and each subject received lists of both lengths. Recognition was evaluated by asking the subject to select each word from the original list from a group of four distractor items. Recall was tested only for the second list presented and subjects were required to name, in any order, as many words from the list as they could remember. Erber's data showed a significant age difference on the recognition task performance, with older subjects doing more poorly, even on lists of 24 words. Her finding of an age difference was a contradiction to the work of Schonfield and Robertson (1966). She observed that her use of only high frequency words had created a more difficult recognition task and thus, even for the 24-item word lists, the difficulty was greater than in the Schonfield and Robertson (1966) study. Choosing high-frequency words embedded in a group of high-frequency alternatives was more difficult due to a lack of novelty and interference created by the higher number of experiences with these words in everyday situations. Erber also obtained a significant age difference on the recall task, with older subjects performing more poorly. Her data suggested that, regardless of the exact processes involved in recognition and recall, neither type of ability is perfectly maintained with age.

Perlmutter (1978) also examined recall and recognition performance in old and young subjects from both high education (Ph.D.) and low education (high school) levels. The learning task used two lists of 24 words. In the first task, the subject was instructed to intentionally learn the words and in the second task the subject was required to generate a number of associated responses to each word on the list (incidental learning). The learning task also used a list of 24 general information fact questions which the subject was requested to answer. All tasks were completed at the subject's own pace. For the recall memory task, they were instructed to write down as many words as they could remember from the list of 24 facts. For the word recognition memory task, they were presented with a random set of words from both of the lists and an additional 48 words not seen before. For the fact recognition memory task, they were presented with the 24 fact statements and an additional 24 statements not seen before. Recognition was tested by responding true or false if the word or the statement had been previously presented. In addition to the experimental measures, Perlmutter also had the subjects predict how well they thought they could perform on these types of tasks and recorded information on the subjects' knowledge and attitudes about memory.

Perlmutter (1978) found that recognition memory was better than recall memory for all groups. Additionally, older subjects correctly recalled and recognized fewer words than younger subjects.

High school educated subjects also performed more poorly than did Ph.D. subjects on the recall and recognition of words. The subjects' recall memory was basically equivalent for both incidental and intentional learning of words; however, recognition memory was better after incidental learning than after intentional learning. Also, the older subjects did more poorly than the younger subjects on the intentional recognition task but not on the incidental recognition task. Recognition for facts was better than recall for facts. Additionally, it was noted that for fact recall, the older subjects did better than the younger and the higher education subjects did better than the lower education subjects.

Perlmutter (1978) proposed that the age difference observed on the intentional memory task and the absence of age differences on the incidental memory task were products of production deficiencies in acquisition processing. When asked to learn, they could not acquire information as well as younger subjects, but when given a strategy for learning (generating associations to words), they were able to perform at a level equivalent to the younger group. The older subjects' better ability at learning facts puts a different perspective on their deficits at learning lists of words and Perlmutter questioned the value of the results of studies that only use list learning to study memory. In regard to the subjects' knowledge about memory, there did not appear to be any difference between age groups in knowledge about memory, inclination to use memory strategies, and competency in monitoring memory performance. The fact that age differences were observed on an intentional recognition task, but were not observed on an incidental recognition task led Perlmutter to conclude that older subjects did not spontaneously use strategies as effective on memory tasks as those utilized by younger subjects.

Hultsch (1975) used a recall task to investigate memory loss associated with aging. He postulated that difficulties with retrieval of information may involve a process of deterioration of the stored information, which he termed trace-dependent loss. Alternatively, he postulated that the loss may involve inaccessibility of stored information, which he termed cue-dependent loss. Thirdly, he postulated that the apparent memory loss may involve a combination of both processes. He proposed that, as a word list is learned, the words are organized into higher order units. These units are then used to facilitate recall.

Hultsch (1975) presented subjects with lists of 40 words, with each word being presented for 1.5 seconds. Each list was composed of four words from each of 10 different categories. Hultsch provided the higher order organization units for the subjects during input by instructing the subjects that they would be presented with a list of 40 words and that the words were from 10 familiar noun categories, with four members of each category grouped together within the list. Following presentation of the list, the subject was given 2.5 minutes to recall as many words as they could. This recall was noncued for half of the subjects and cued (with the names of the 10 categories of words being provided) for the remaining subjects. The same word list was presented and tested in exactly the same manner across six consecutive trials for each subject.

Hultsch (1975) generally found that young subjects performed better than older subjects on both the cued and uncued recall tasks. Specifically, in looking at how many categories were recalled (as measured by remembering any word from that category) the younger group again did better. The younger subjects were also able to recall more words for each category recalled than the older adults. The results indicated that older subjects had more difficulty in recalling the higher order units (categories), which would suggest the process of cue-dependent forgetting. The older subjects also recalled fewer words per category, however, which suggests poorer performance even though the higher order unit was available and provides evidence for trace dependent forgetting. Hultsch's data were unable to provide unequivocal support for the importance of either factor, thus suggesting both processes may be involved.

Smith (1977) also investigated adult age differences in memory for words with a cued recall task. In an attempt to determine whether decreased memory performance with aging was due to storage or retrieval difficulties, Smith manipulated factors at the time of encoding and retrieval. The manipulated factors were whether the words were cued or noncued and the type of cue provided. The cues given were either structural (the initial letter of the word) or semantic (cateory label). The word list consisted of 20 words presented at the rate of 3 seconds per word. Each word in the list began with a different letter and was a member of a distinct category. Half the subjects were provided with cues prior to list presentation and the relationship of the cues to the upcoming words was explained. Of the subjects receiving the cues prior to list presentation, half were given each type of cue and were given the same type of cue at recall as they had received prior to list presentation. Following the presentation of the list, all subjects were initially given a three-minute free recall period followed by a three-minute cued recall period.

In Smith's (1977) study, providing cues at the time of retrieval was expected to reduce the difference observed between young and old subjects if the decrease with aging was due to a retrieval problem. Smith's results indicated that, overall, younger subjects were able to recall more words than older subjects and semantic cues during recall were more effective than structural cues. More specifically, when no cues were given prior to list presentation, younger subjects showed significantly better recall than older subjects, regardless of whether recall was cued or not. When cues were presented at the time of encoding, whether recall was cued or not, the recall difference between older and younger subjects was not significant if the cues were semantic, but was significant if the cues were structural. Also, when semantic cues were given both prior to the list and at the time of recall, the superiority over structural cues was larger than if the semantic cues were given only prior to the list or at the time of recall. It was noted that when this optimal cuing situation was created by providing semantic cues both at the time of input and recall, there was no significant difference between young and old subjects. Smith (1977) suggested that the results supported the retrieval deficit hypothesis by nullifying the age difference with the appropriate retrieval cues.

In a further effort to distinguish between an encoding and retrieval explanation of age differences in memory performance, Smith (1979) presented young, middle-aged, and older adults with 11 consecutive lists of high-frequency words. The lists consisted of 10, 20, or 40 words and were presented at a rate of 2 seconds per word. The first and last word lists presented were not tested, but the remaining nine word lists (three each of the different lengths) were tested in a delayed recall procedure. Each of the nine lists were tested for a three-minute free recall period, not immediately following its presentation, but following the presentation of the subsequent list. The order of the word lists was such that each different length of list was presented once following a list of equal length and once each following lists of the two other lengths.

Smith (1979) proposed that if retrieval difficulties were the major effect in aging, it would be expected that the longer the stimulus list was, the more difficult recall would be. If the storage interval was the key element that impacted on the difficulties for the older subjects, then the length of the intervening word list would be important. He then examined the percentage of words recalled for old, young, and middle-age subjects as a function of list length and length of the list presented during the retention interval. Smith expected that retrieval problems in older subjects would be revealed by an interaction between list length and age.

Storage difficulties were expected to be evident as an interaction between age and the length of the list presented during the retention interval.

Smith's data (1979) ruled out a storage interference effect, but he did find a significant interation between age and list length. His interpretation of the data was not as a simple retrieval difficulty in older subjects. He felt the difficulties of older subjects may have been due to the organizational processes used during encoding. He felt younger subjects actually are able to make more use of organization during encoding but the longer list length prevented them from organizing and thus created the interaction effect.

Serial Position

Recall memory has often been examined in terms of the serial position of the items during presentation. This has been termed the serial position effect. Specifically, the serial position effect reflects the fact that items at the beginning of the list (primacy effect) and those at the end of the list (recency effect) tend to be recalled better than those in the middle of the list. This creates a "U"-shaped distribution when word recall is graphed across word position. A broad background of research exists on the serial position effect which allows a basis for interpretation of any aging factors that might be seen to influence the normal pattern (Salthouse, 1980). It has been thought that serial position effects are a product of rehearsal strategies in that the primacy effect is generally the product of the initial items being rehearsed more and the recency effect is a product of the end items being presented and rehearsed later (Brodie & Prytulak, 1975). In addition, a number of factors are already known to affect the recall of items from various positions in the list. This past research provides a number of avenues by which to approach the effects that aging might have on the serial position effect.

Brodie and Prytulak (1975) investigated the variables that may modulate the serial position effect. Their intention was to demonstrate that rate of presentation of the items and the delay period before recall would significantly affect the shape of the serial position curve. Their design used 12 word lists of 18 one-syllable nouns. Each word had a frequency rate of between 50 and 300 occurrences per million. They presented the words at rates of one every 1.25, 2.5, or 5 seconds. Recall was either immediate or delayed for 15 seconds, with an interfering task in between.

Brodie and Prytulak (1975) found that recall from the primary portion of the curve decreased with increased presentation rate. They also found that delaying the recall for 15 seconds resulted in poorer recall for terminal items. They concluded that the serial position effect, delay of recall, and presentation rate of the words alters free recall through a process of altering rehearsal time and item retention interval. From their investigation, they concluded that the "U" shaped serial position curve observed in free recall is a product of the beginning items being rehearsed more often and the terminal items being rehearsed later in the learning situation.

Raymond (1971) made one of the initial attempts at examining the serial position effect with an older population. Raymond presented subjects with eight lists of 12 high-frequency words (the first list was practice). Each word was presented for 4 seconds with 4 seconds between words. The subjects read each word aloud and then, at the end of the list, wrote down all the words they could remember. Raymond proposed that short-term storage generally accounts for the recency effect and long-term storage accounts for the primacy effect in free recall of stimulus lists. She used a long presentation time, high-frequency words, and a fairly short list length to maximize potential recall from long-term storage. Her experimental observations demonstrated a lower primacy effect than is usually seen and a definite recency effect. This finding suggested that short-term storage was not impaired in the elderly but that, even under favorable conditions, long-term storage abilities decreased. However, some caution should be used in generalizing from her results. Raymond's study did not include a young comparison group and the comparisons were made with previous studies in the literature. Additionally, her subject population was drawn from a residential facility for the aged and may not have been a representative age group sample for "normal" community living older adults.

Arenberg (1976) investigated the shape of the serial position curve in the young and older populations. Previous work that examined short-term memory demonstrated better performance through simultaneously providing an auditory stimulus as well as a visual stimulus (Arenberg, 1968), for example, having the experimenter speak the word as it was presented on a screen. Further, an active auditory stimulus, in which the subject pronounces the word, has been found to be more effective than a passive auditory stimulus, in which the subject hears the word pronounced by someone else (Arenberg, 1968). Arenberg recognized this variable of auditory augmentation in his presentation of task items. Arenberg presented lists of 16 high-frequency words at the rate of one second per word with two seconds between words. He had three different conditions in which a subject either said the word aloud as it appeared, listened to the word being said as it appeared, or merely looked at the word presented. Arenberg's findings were that, throughout the serial position curve, the younger subjects recalled more words than the older subjects. Additionally, both age groups benefited equally from auditory augmentation for items at the end of the list. It was also found that, for older subjects, augmentation had a detrimental effect on memory for items from the beginning of the list. It appeared that adding the activity of vocalizing the word created a divided attention task and added to the memory load required to perform, resulting in decreased performance.

Salthouse (1980) examined the effects of rehearsal time on free recall in both young and old populations. He postulated that increasing the number of syllables in a word would require more time for rehearsal. If older adults do poorer on memory tasks because of slower rehearsal, then the difference between three-syllable and one-syllable words should be similar to the difference between old and young subjects. Salthouse presented subjects with five lists of 12 words each for both one-syllable and three-syllable high-frequency usage words. He presented the words for 1.5 seconds with 2 seconds between words. Subjects were tested for free recall at the end of each list. Also, Salthouse had the subjects rehearse the words either once, twice, or three times to indirectly provide another estimate of their speed of rehearsal.

Salthouse (1980) observed a similar pattern of serial position effects in young and older adults, and noted that both age and increased number of syllables had similar effects in decreasing the subjects' performance across all word positions. He also found that older subjects exhibited longer rehearsal times than younger subjects on his indirect measure of required number of rehearsals. As a result of his data, Salthouse suggested that older subjects may do poorer on memory tasks because of a slower speed of rehearsal. He further suggested that a slower speed of mental operations in the older population may account for age-related memory problems.

Wright (1982) further evaluated the possibility that older subjects may show less of a recency effect due to a change in short-term memory capacity. Part of Wright's evaluation was based on analysis of Salthouse's (1980) study, presented earlier. Salthouse's study had involved the presentation of 10 lists of 12 high-frequency words. Wright's evaluation suggested both old and young subjects have the same short-term memory capacity, although the younger subjects were able to recall more words in total. She further observed that for both age groups, the primacy effect decreased from the first to the last list, while the recency effect increased.

Wright additionally looked at the order in which the words were recalled. She found that, as the subjects progressively completed more lists, items from the end of the list were recalled earlier in the recall sequence and items from the beginning of the lists were recalled later in the recall sequence. She concluded that her data were consistent with Raymond (1971) in showing no age difference in short-term memory and suggested that the age difference lies in long-term memory.

Arenberg (1976) had artifically attempted to manipulate rehearsal strategy and had found it actually to be detrimental to the older subjects. Wright's analysis (1982) suggested that the older subjects attempt to approach the task much the same as the younger in that a disproportionate amount of rehearsal time seemed to be allotted to initial items from the list. Thus, although their serial position curve tended to be weighted towards a stronger primacy effect, this effect and the resultant pattern was similar for both older and younger subjects. Wright could not observe a qualitative difference in the way both groups of adults learned the list.

Prose Memory

Recent work in aging and memory has also examined adult age differences in prose memory. In a precursor to some of the aging research, Brown and Smiley (1977) investigated how children learn to remember passages of prose. They found that the linguistic units which are more important to the structure and theme of a passage are the most dominant in recall of the material.

Brown and Smiley (1977) measured the recall of fairy tale stories. The stories were first divided into individual units, each of which contained a distinct idea and/or represented a place where the reader might pause. The separate units were then ranked on a four-point scale as to their importance to the theme of the story. The ranking was done by eliminating (in three steps, one-fourth of the units at a time) the units judged to be the least important to the theme of the passage. The subjects were auditorily presented stories and subsequently asked to recall the gist of the story. Their data showed that all subjects demonstrated better recall for the more important units and recall increased with increasing grade levels. Further understanding of how older subjects deal with memory for prose material may give insight into the functional aspect of memory difficulties with aging.

Meyer and Rice (1981) investigated the recall of prose passages among young, middle age, and older adult age groups. They felt that recall of prose material depended on the importance level of the separate ideas within the organization of the passage. If older adults' memory strategies result in them not being able to make use of the hierarchical organization of the prose material, then it may be that their use of organization is a factor in their decreased memory abilities. Therefore, in the recall performance of older adults, the expected pattern would be that they would recall main ideas just as often as the non-essential details.

In the Meyer and Rice (1981) study, the subjects read a 641-word passage concerning parakeets as pets. They were then tested for free recall, filled in a partially completed outline in regards to major points within the text, and answered questions dealing with either highly or less important material from the text. The results demonstrated that all three age groups were sensitive to the main idea of the text, with the material of highest importance being best remembered. However, it appeared that the younger subjects were more sensitive to the hierarchical organization of the passage, since the younger adults remembered more of the major details than the older adults, while the older adults remembered more of the non-essential details than the younger adults.

The Meyer and Rice (1981) study used adults of high vocabulary ability. They suggested that some age-related deficits in information processing may be minimized for subjects with above average vocabularies and who are familiar with similar types of reading materials. The verbal ability level of the subject may be an important factor when looking at recall of prose material in a learning task.

Dixon, Simon, Nowak, and Hultsch (1982) further examined adult age differences in prose memory as a function of the importance level of the information in the passage. Also, the effects of input modality (reading or listening) and retention interval (immediate or one week delay) were examined. They noted that past research in prose memory has suggested a "levels effect," in that the main ideas of a text are remembered better than the details. Additionally, Dixon et al. (1982) noted that past research suggests that older adults may not use organizational strategies as well as younger adults. Their experiment involved the presentation, either as written material or on auditory tape, of five news articles, each approximately 180 words long. Following each article, the subjects were asked to write down everything they could recall about the article. After one week, the subjects were given the title of each article and asked to write down all they could recall.

The results of the Dixon et al. (1982) study indicated that younger adults tended to remember the material better than older adults under both immediate and delayed recall conditions. The age-related discrepancies for recall were more pronounced for main ideas of the text as compared to the less important details. This again suggests that older subjects have difficulty in identifying or making use of the hierarchical structure of the text. Additionally, the findings suggested that the size of the age-related difference was bigger if the material was read by the subject rather than presented auditorily. Dixon et al. (1982) noted that there may be variables within the subjects, such as verbal ability or interests, that could have mediated the pattern of results observed.

Petros, Tabor, Cooney, and Chabot (1983) also completed an investigation of age differences in prose memory. Their research varied the rate of presentation and the difficulty level of the material for younger and older adults of both high and low levels of education. The speed of presentation was varied in order to create a memory task with either more (fast rate) or less (slow rate) demands on the processing capacity of the subjects. If older subjects are slower at accessing information from long-term memory and manipulating it within short-term memory (Salthouse, 1980), then age deficits should increase as rate of presentation increased. Previous prose memory research (Meyer & Rice, 1981; Dixon et al., 1982) had not controlled for the verbal ability of the subjects, so Petros et al. (1983) selected half the subjects from a high-education background and half from a low-education background.

In the Petros et al. (1983) study, the subjects listened to two narrative passages at a slow rate of speech. The passages had previously been divided into four levels of importance units. The subjects were asked to recall each story immediately following its presentation. The results showed that younger adults recalled more idea units than older adults at both education levels. Additionally, subjects at both age levels and education levels demonstrated sensitivity to the importance level of the idea units. Their second study proposed to vary the requirements on the processing capacity by manipulating text difficulty and speed of presentation. They found that age differences in recall for idea units were larger for difficult than for easy passages, but presentation rate did not affect the size of the age difference observed. However, subjects at all ages and education levels favored the main ideas in their recall relative to the non-essential details.

Zelinski, Light, and Gilewski (1984) further investigated age differences in memory for prose material. They pursued the idea that older adults may not be as sensitive as younger adults to the hierarchical levels of importance in prose material. In several experiments, they evaluated the effects of age on sensitivity to levels of importance in a passage. They evaluated the subjects' performance on both immediate and delayed recall and with different difficulty levels of prose passages. They used subjects of various verbal ability levels. The findings suggested that higher-level information was recalled better than lower-level information for both young and old adults (a levels effect). The older subjects were not found to be any less sensitive to the importance level of the information, although the older adults recalled less information than the younger adults. The pattern of results did not depend on the verbal ability of the subjects or the type and length of the material presented.

The difference between older and younger subjects' prose recall has been found to be more pronounced at higher levels of text information in some studies and more pronounced at lower levels in other studies. Dixon, Hultsch, Simon, and Von Eye (1984) suggested that subjects' verbal ability may account for the different results observed. Their review of past research also suggested that the age difference was more pronounced for lower level information in well-structured texts and more pronounced for higher level information in less-structured texts. A well-structured text would present the main idea early in the text and follow it with less important clarifying material. They chose to use well-structured texts, but varied the number of concept items. With more concepts, they felt the text should take longer to process, a factor which might negatively affect the older subjects' sensitivity to the hierarchy of structure. Their results demonstrated an overall decline in recall ability with age. More importantly, it was found that with a low verbal ability population, the largest age differences in recall were found for the main ideas of a passage. However, for adults with high verbal ability, the largest age differences in recall were for information that was least important to the theme of the passage. The younger adults were able to recall the main ideas of texts involving either many or few concepts, while the older adults recalled more of the main ideas when the text involved fewer concepts than when the text involved many concepts. Both the younger and older subjects recalled more details of the text when the text contained many concepts.

Theoretical Explanations

Although the literature on recall of prose material has provided documentation for definite decreases in prose recall associated with aging, conflicts exist. Much of the work indicates a similar pattern of recall as a function of importance level for both young and old adults. Furthermore, research with word lists also indicates that young adults recall more than older adults but the pattern of the serial position effect is similar in both age groups. With the commonalities observed for both prose and word list memory, it would seem worthwhile to pursue a common theoretical line of thought that would account for the data in both areas. Craik and Simon (1980) suggest that the level of semantic processing involved in learning may be a significant factor underlying age differences observed. Their hypothesis is that deep, elaborate processing is especially effortful and requires more "cognitive energy" from an individual. They suggest that the ability to deeply process material deteriorates as a person ages. Thus, older people would have less distinctive and discriminable memory traces resulting in decreased performance on memory tasks. Salthouse (1980) suggests a "rehearsal-speed" hypothesis to account for differences in memory between young and old subjects. He proposed that older subjects tend to process items at a slower rate and thus, when performing a memory task, have less time available for processing each item. The Craik and Simon (1980) and Salthouse (1980) hypothesis may actually be looking at a quite similar phenomenon. It may be, as Craik and Simon have suggested, that the depth of processing is the critical determinant of memory for an item but that older people require more time to achieve equivalent levels of processing. They are thus limited, not by inability to correctly encode items, but by a lack of time and cognitive energy to optimally perform the task. If memory tasks involve a number of skills or demands on processing capacity, then variables that influence the type of mental manipulations involved in the memory task should result in differential levels of performance. Some tasks may be more taxing to the capacity level of functions and thus result in a decreased performance by the elderly. It would seem useful to further investigate how the speed of cognitive operations affects memory ability and how it may be a factor underlying age differences in memory performance.

Cognitive Slowing

The next section will review the literature specifically in the area of research concerned with the slowing of cognitive operations that may be associated with aging. Birren (1974) proposed that, with advancing age, individuals demonstrate a slower rate of central nervous system operations. This slowing would cause perception and memory to be less efficient and could alter retrieval of previously learned material. Birren further suggested that the slower speed of cognitive operations could be reflected in a slowing in decision making and a decreased ability to discriminate relevant from irrelevant information.

Thomas, Fozard, and Waugh (1977) examined the cognitive slowing hypothesis by use of a task which was designed to measure retrieval from long-term storage. They chose this approach to avoid the differences in strategies which may be involved in the learning of new material. They felt that using a task involving the naming of pictures of objects would only involve the retrieval of overlearned information with long-term storage. In their experiment, each subject was presented with eight blocks of 32 trials with each block using the same set of stimuli. A ninth block of trials was then presented that used a novel set of stimuli. Each block began with 16 naming trials in which the subject was shown a picture and asked to name the object as quickly as possible. Following these initial trials, there were 16 trials in which the subject was shown a word prior to each picture. One half of these were "matching" trials (the word named the picture) and one half of these were "nonmatching" trials (the word named a different object than the picture). Each sequence of pictures consisted of two words from each of eight different groupings of word frequency.

The results found by Thomas et al. (1977) were that response times were longer for older adults compared to younger adults and that response times decreased across trials for all subjects. Additionally, significant age x practice, age x cue, and age x type of task interactions were demonstrated. The age x practice effect indicated that the difference in response time between the younger and older subject groups decreased over the course of trials. The age x cue effect indicated that the difference between the younger and older subject groups was less when the trials were cued. The age x type of task effect indicated that the older subjects demonstrated a larger discrepancy than the younger group did between their performance on the matching task and their performance on the naming and nonmatching tasks. The hypothesis that Thomas et al. (1977) proposed to explain their results was that, by practice or by cuing, they were decreasing the difficulty of the naming task and therefore minimizing the effects of age.

In a followup to this work, Waugh, Thomas, and Fozard (1978) studied the length of retrieval time from primary memory, secondary memory, and lexical memory as it varies over the variable of age of the subject. They viewed short-term memory as involving two independent storage systems, labeled primary and secondary memory. Primary memory is a limited capacity storage of only recently presented items, which are quickly displaced by subsequent input and forgotten. Secondary memory is a relatively stable system of much larger capacity, to which items of information are transferred out of primary memory. Lexical memory was viewed as the memory system used to attach meaning to an overlearned symbol, such as reading a word. Primary memory was measured with a paired-associate task in which 12 lists of pairs of three-letter words were presented. Each pair was presented individually for two seconds each, the average list length was two pairs, and the subject was required to respond with the second member of the pair for only the last pair presented in a list. Secondary memory was measured through the learning of a list of 12 paired associates. The subject was tested only after the entire list had been learned and was required to provide the second member of a pair when presented with the first member. Lexical memory was measured by the time interval between the presentation of a word on the slide and the beginning of a response (naming the word).

Waugh et al. (1978) found that retrieval time from both primary and secondary memory increases with older populations and that the effect of age group on secondary memory was more pronounced. They also noted that the effect on secondary memory is observed with middle-aged groups (around age 50) while the effect on primary memory is observed in slightly older groups (around age 60). Lexical memory was observed to slow only slightly and this was observed for the older age group (around age 70). The importance of these observations for the use of memorization tasks in studying aging was suggested. For example, if rote memorization involves the use of mediators to integrate items and these mediators are obtained from secondary memory, then the older population would be at a disadvantage in a conventional verbal learning task.

Bowles and Poon (1981) investigated the effects of aging on the time required to access words in the lexicon. They also attempted to identify a usable technique for correcting for sensorimotor slowing in older subjects in order to lessen the potential effects of that slowing as an extraneous variable and obtain a more accurate measure of lexical access time. They presented subjects with pairs of words, nonwords (N), or a mixed pair that contained a word and a nonword. The words were high frequency (H) or low frequency (L) (Kucera & Francis, 1967). The possible types of "word" pairs that were presented were H-H, H-L, H-N, L-L, L-N, and N-N. A list was constructed consisting of 120 pairs of stimuli, composed of 20 each of the six possible combinations of pairs. Initially, 50 reaction time trials were presented to establish an estimate of sensorimotor reaction time. The subjects' responses were made by moving their fingers off of either of two response keys. During the reaction time trials, they moved their finger off of either the upper key or lower key, depending on which word (upper or lower) appeared on a screen in front of them. During the presentation of the word list, subjects were instructed to move their finger off the upper key if both the "words" presented were real words and off the lower key if both the "words" were not real words.

The results of Bowles and Poon (1981) suggested that there is a sensorimotor slowing with age. An age x pair analysis of response latency showed main effects of both age and pair type. The older subjects demonstrated significantly longer response latencies and all subjects' responses were significantly slower when the decision involved a nonword as one part of the pair. More specifically, the slowest response was observed to the L-N pair, followed by the H-N, the N-N, the L-L, the H-L, and the H-H pairs, in decreasing order of response latency. The largest difference between the old and young groups was observed for the L-N pair, followed by the H-N and N-N pairs, respectively. The older and younger groups were not significantly different in the accuracy of their decision making. Although they found a significant age effect, they did not find an age x word frequency interaction effect. Since word frequency had been shown in previous experiments to be a factor at the lexical access stage of processing, they concluded that, due to the lack of finding an age x word frequency interaction effect, age must be a factor at some stage of processing other than lexical access. Therefore the age difference in lexical decision latency must be due to factors occurring at a stage other than the lexical access stage.

Bowles and Poon (1981) had attempted to use a control task for measuring reaction time without lexical access. Their intention was to use that measure to correct for sensorimotor differences when comparing response latencies between younger and older subjects. In their analysis, they computed the difference between the subjects' lexical decision time and their reaction time control measure and performed an analysis of variance on those data. Significant main effects of age and pair type were found, but no significant interaction. This finding was interpreted as supporting the existence of an age difference in mental processing time beyond that attributable to slower sensorimotor processing. However, when viewing their results, Bowles and Poon questioned the accuracy of their control task. Issues were raised concerning whether the control task involved different processes or possibly different amounts of time to complete the same processes and they ultimately felt that it was not the best approach.

In their approach to the measurement of lexical access, Cerella and Fozard (1984) postulated a three-stage model of word perception. The hierarchical stages were proposed as encoding, followed by lexical access, followed by vocalization. By comparing two tasks, using one which isolated the first and last stages (and should require no lexical access) and using another which involved all three stages, they were able to provide a pure measure of lexical access. The task that involved all three stages was to name a target word out loud as it appeared on a screen. The task that did not require lexical access was one in which the stimulus word appeared but the subject was not to name it until after it had disappeared and a signal to respond appeared on the screen. Reaction times were measured to these tasks and, by subtracting the latency of the second task from the first, they isolated a measure of lexical access. Lexical access time as measured in their study was not found to change significantly with age.

Investigators have examined the cognitive slowing hypothesis by also examining the speed of accessing category information from long-term memory. Eysenck (1975) investigated retrieval from semantic memory with both a recall and a recognition task requiring category discrimination. The basic task involved presenting subjects with a category name (e.g., fruit). The recall task required the subjects to provide an example of that category, beginning with a given letter (e.g., fruit-A) as soon as possible. The recognition task required a yes/no response as to whether a given example (e.g., fruit-apple) actually was a member of that category. Eysenck found that older subjects responded more slowly on the recognition task than the younger subjects, while no significant age differences were found on the recall task. Retrieval from semantic memory was felt to involve both a search and decision component. Eysenck (1975) felt that the older subjects may retrieve the information as fast as or faster than the younger, but their slower response time on the recognition task was due to a longer length of time in the decision making process itself. Thus, in a task requiring minimal search and then a decision (recognition) the younger subjects performed more quickly. In a task which involved both a search and decision process (recall), the older subjects' hypothesized faster searching ability offset their slower decision making.

Byrd (1984) also examined adult age differences in the speed of accessing category information from long-term memory. Both older and younger subject groups were presented with two types of tasks. The "decision" task was to decide if the second word presented was an example of the category named with the first word (e.g., Fruit: Pear). The "generation" task was to provide an example of a category, when presented with the category followed by the initial letter of the response (e.g., Fruit:P...). These two tasks were then presented either in blocks of trials of the same type of task or in a mixed order of both types of tasks. In the blocked trials condition each subject was presented with four blocks of generation trials (six trials per block) and four blocks of decision trials (12 trials per block). In the mixed trials condition the subjects were tested in the same manner, however each block of trials was composed of a random mixture of both generation and decision types of trials. Byrd found that the older subject population had a longer response latency than the younger adults on both the generation and decision tasks. It also appeared that the younger subjects benefited more from having the predictability of the blocked sets of trials for the generation task. The young group's response latency was considerably more facilitated than the older group in the positive effect that having blocked trials had on them. Thus, the younger adults appeared better able to make use of the added information in the blocked trials condition.

In the second part to his experiment, Byrd (1984) presented both older and younger subject groups with only the "decision" type of task mentioned above. In this portion, two decision tasks involving the same category were presented with either none, one, or two irrelevant intervening tasks. The intervening tasks consisted of incorrect examples of various new categories. For example, a subject being presented with one intervening task may receive a sequence such as FRUIT:PEAR, ANIMAL:CHAIR, FRUIT:APPLE. A subject receiving a second presentation of the same category is seen as "primed" and should respond with a shorter response latency. The various intervening tasks should eliminate this priming effect. Byrd again found a slower latency of response for the older subjects and also found that, for both the older and younger groups, the response to the second presentation of a category was faster when no intervening tasks were presented than when either one or two intervening tasks were involved. No significant interaction of age x intervening task was found. Byrd concluded that by activating the semantic memory networks through repetition of the same task (felt to be an "automatic" processing strategy provided to the subject by the design of the task) the older and younger subjects were equally facilitated by the nature of the task. Thus, there does appear to be a difference between young and old subjects in the facilitation of reaction times when presented with "effortful" (blocked trials) versus "automatic" (priming by a previous trial) types of tasks. The effortful task relies on some internal activity of the individual while the automatic task is facilitated by the way it is set up. This research suggests that the younger subjects are more capable of this internal activity than are older subjects.

In a subsequent study, Mueller, Kausler, and Faherty (1980) examined slower memory access time for three different types of memory codes. They presented subjects with two words simultaneously, and asked subjects to make one of three decisions as quickly as possible. The decisions involved were whether the two stimulus words were physically identical (spelled and looked exactly the same, e.g., MEET-MEET), homophones (two different words which are pronounced the same, e.g., MEET-HEAT), or members of the same taxonomic category (e.g., INCH-YARD). Each subject was presented with three sets of 60 word pairs. One set involved the physically identical (PI) decision and included 30 pairs that were PI and 30 pairs that were not PI. Another set of 60 included 30 pairs that were homophones and 30 that were not. The other set included 30 pairs that were categorically related and 30 pairs that were not. Each set of 60 pairs was presented four times. The subject responded by pressing keys marked "same" or "different" according to the task at hand.

Mueller et al. (1980) found that, overall, older adults performed more slowly in making these decisions than younger adults. Also, a significant age x decision interaction effect was found. More particularly, the younger adults' decision making time was the longest for the taxonomic task, shorter for the homophone task, and the shortest for the physically identical decision task. The older subjects also demonstrated their shortest latency on the physically identical task, with the homophone and taxonomic task both being longer, but not significantly differing from each other. The older adults also demonstrated a practice effect over trials but not to the extent that they reached the performance level of the younger adults. The conclusion of the researchers was that the aging differences were not attributable to slower speed of access, but rather to differences in utilization of strategies for decision making. Although the size of the difference between young and old appeared greater for taxonomic decisions compared to spelling decisions, proportionately it was equivalent. It was felt that the older population could appropriately access the materials, but worked through the subsequent decision making process more slowly. One explanation for why this may be is that the older adults' interpretation of a category is more broad, thus making the decision more difficult.

In a followup to the research of Mueller, Kausler, and Faherty (1980), Mueller, Kausler, Faherty, and Oliveri (1980) proposed to determine the influence that the specific type of decision task involved will have on making category judgments. In looking at previous research, they hypothesized that older subjects may take longer to make a decision because their concept of categories is less well defined. The authors felt that in addition to the expected difference in category boundaries, the older adults may experience a higher anxiety-arousal level. This could be of a chronic nature (which some previous research had indicated) or may be in response to the threat of being evaluated. The younger subjects were divided into high and low anxiety groups, based on their scores on the Spielberger Test Anxiety Inventory. The decision making task involved "typical," "atypical," and "unrelated" examples of categories in a task that required subjects to respond as quickly as possible as to whether the second word of a pair was an example of the stated category (e.g., ANIMAL-DOG). Each pair was presented once in each of two blocks of 120 trials and each of the 15 different categories was paired with two typical instances, two atypical instances, and four unrelated instances. Following the decision making response time trials, cued recall data was collected with the retrieval cue consisting of the previously presented categories.

The results of Mueller, Kausler, Faherty, and Oliveri (1980) showed the groups' main effect to be significant. Older subjects had the slowest response time on the decision task, followed by the high anxiety younger group, with the low anxiety young group exhibiting the shortest response latency. In specifically looking at the typicality variable, a groups x typicality interaction effect was found. The older group performed equivalent to the high anxiety young group when making an atypical decision and both showed slower reaction times than the low anxiety young group. When making either typical or unrelated types of decisions, the two young groups were comparable to each other and faster than the older subject group. On the recall measure, a significant group effect was found for atypical instances only. The young low anxiety group recalled more atypical instances than the other two groups. Also noteworthy from the recall data is that the older subjects did not show as much of a decline in recall for atypical instances relative to typical instances as the young adults. The conclusion was that the older subjects did not seem significantly different from the high anxiety younger group in making marginal (or atypical) decisions. However, for typical decisions, the major difference between the groups seemed to be a product of the age factor. The authors stated that differences potentially caused by anxiety should not be ruled out in aging research, but also observed that the performance deficit observed in older subjects seems due to more than just higher anxiety.

Petros, Zehr, and Chabot (1983) examined age differences in the speed of accessing physical information about words, the names of words, and semantic category information about words. Subjects were presented with two words simultaneously and asked to decide if the two words presented were physically identical (e.g., dog/dog), if the two words had the same name (e.g., DOG/dog), or if the two words were from the same semantic category (e.g., dog/cat). For each type of decision, half of the trials used words that were highly typical examples of their category and half of the trials used less typical examples. The words were presented in both upper and lower type face. For the semantic decision task, the words were correctly judged to be from the same category regardless of the type face. Each subject was presented with three blocks of 35 trials each. Each block consisted of 20 positive trials and 15 negative trials, all involving the same type of decision. The subjects were told in advance of each block of trials what decision would need to be made and their response was to push a button to indicate whether each trial was or was not a positive example of that task.

The Petros et al. (1983) study found significant main effects of age, response type, and typicality level. These effects were represented in the observations that younger adults responded faster than older adults, positive responses were faster than negative responses, and highly typical item pairs were responded to faster than were less typical pairs. Additionally, a significant age x decision type interaction was found. This indicated that older adults were slower than younger adults for each type of decision, but the age difference was greater for semantic decisions. These results indicate that older adults were slower than younger adults at accessing information from long-term memory. The results also indicate that the observed age differences in retrieval speed increased as more information was required to make the necessary decision (as is the case in semantic decision making). The authors suggest that the slower speed of semantic access may limit the available processing capacity of older adults and impair retention performance.

In a follow up to the work of Petros et al. (1983), Madden (1985) conducted an experiment using three tasks with the same types of judgment involved in all three. Madden felt that the type of judgment and the type of information retrieved for making decisions in the Petros et al. (1983) study varied across the different experimental conditions. He attempted to isolate the retrieval time for letter identity and semantic information without involving comparison and decision processes. The judgment task remained the same for all tasks and required the subject to respond yes or no to the implicit question, "Do these two words mean approximately the same thing?" The positive response trials required the subject to correctly identify identical word pairs (e.g., BUTTON/BUTTON), words different only in letter case (e.g., COPY/copy), and synonym words (e.g., target/goal). The negative response trials included any presentations which were not examples of "approximately the same thing" (e.g., TRAIN/CAKE or plate/OAK). The testing sequence involved five blocks of 30 trials each.

Madden (1985) found significant main effects of age and word pair type. The older subjects were slower than the younger subjects in responding. Identical word pairs were identified the quickest for all subjects, followed by words differing only in letter case, followed by synonym words. An age x word pair type interaction was found to be significant, indicating that the age difference in response time between the older and younger groups increased as the amount of semantic information required increased. Madden (1985) computed an estimate of the time required for retrieval of letter information by subtracting the reaction time for the same case-identical words from the reaction time for the different case-identical words. He estimated the semantic retrieval time by subtracting the reaction time for the different case-identical words from the reaction time for the synonym words. He found both types of estimated retrieval time to be slower for the older adults. Thus, the older adults were slower in letter information retrieval and semantic retrieval but the proportion of slowing for the older adults was the same for all tasks. The results were interpreted to represent a generalized age-related slowing in the speed of information processing, and not increasing as a function of type of information retrieved.

At this time, we seem to have somewhat mixed results as to the exact nature of the processes which result in slower response time in aging. By manipulating certain aspects of the task, the effect can be observed to a lesser or greater extent. In their earlier reviews of the literature, Waugh and Barr (1980) and Salthouse (1980) felt that there was adequate documentation to suggest that older subjects are slower than younger subjects in encoding data and processing either simple or complex information. Their evaluation suggested that the speed loss, or cognitive slowing, interpretation of the age-related memory problems seemed to be the most useful at that time.

In another review of the literature, Burke and Light (1981) have proposed a somewhat different framework. They propose that age-related changes may involve changes in operations involving both encoding and retrieval of information. They stress the potential role of contextual and semantic processes in both recall and recognition. Their review serves to further demonstrate the variety of findings in the field of memory and aging research and the difficulty in accounting for the findings due to the variety of approaches taken.

Verbal Ability

The previous research reviewed has also involved some assessment of the individual differences of the subjects that modulated the size of the age differences observed. One area that has proved to be of some interest is the verbal ability of subjects. This has involved grouping of subjects according to education (Perlmutter, 1978; Petros et al., 1983), according to vocabulary ability (Meyer & Rice, 1981), and according to a group of tests designed to assess verbal ability (Zelinski et al., 1984). An additional area of research in the area of aging and cognitive processes that would appear worth further attention is work being done in the area of verbal abilities and how they may be an influencing factor, modulating the size of the age differences observed. The significance of slower cognitive operations in aging suggests that the variable of verbal ability would be a significant factor in this process. The research presented will suggest that differences in verbal ability relate to differences in the speed of accessing information in the lexicon and manipulating information in working memory.

A major effort at assessing the importance of verbal abilities in the speed of cognitive operations was the work of Hunt, Lunneborg, and Lewis (1975). They studied the information processing abilities of individuals as a function of their more general verbal ability. Their purpose was to ascertain how much verbal skill abilities influence a person's more general cognitive functioning. Verbal ability was defined as the combined ability of: knowledge of the meaning of words, syntactic rules, and semantic relationships between the concepts noted by words. The focus of their research was on verbal ability (as measured by the Washington Precollege Test) as it related to an individual's current information processing abilities (CIP). CIP was felt to include: (1) the sensitivity of overlearned codes to arousal by incoming stimulus information, (2) the accuracy with which order information can be processed, (3) the speed with which the internal representations of short and intermediate memory can be created, integrated, and altered. Thus, their analysis of verbal abilities is an offshoot from and directly related to the speed of mental processing research.

In a series of experiments, Hunt et al. (1975) found a number of differences between high and low verbal ability subjects. Their subjects were from freshman classes at the University of Washington. The high verbal subjects were students who scored within the upper quartile of the Washington Precollege Test and their low verbal group had scored within the lower quartile (which would suggest that they were likely within the average range for the population as a whole). The initial experiment involved the presentation of pairs of the letters A and B. The letters could appear in either upper or lower case. The task involved deciding if the pair was the "same" or "different." In the physical identity (PI) condition the subject responded "same" only if the two letters were exactly the same (AA, aa, BB, bb). For the name identity condition (NI) the subject responded "same" if the two characters referred to the same letter (e.g., AA or Aa). The subject responded by pressing either of two response keys marked "same" or "different." Following 40 practice trials, the subjects were presented with a randomized group of 80 PI trials, 80 NI trials, and 160 trials with letter pairs which were neither PI or NI. The difference in response time between PI and NI trials was viewed as a measure of the added time required to retrieve the name associated with each letter. This added time was found to be significantly longer for the low verbal ability group and suggested that the high verbal group could access highly overlearned material in long-term memory more rapidly than low verbals.

The second Hunt et al. (1975) experiment involved the consecutive presentation of two syllables. Each of the syllables was pronounceable but did not have any meaning unless paired with the appropriate partner. With the correct first and second syllable, the pair formed an identifiable word (which then represented an overlearned code). An example would be the pair of "prob" and "lem."

They are not meaningful independent of each other but together are highly recognizable and it was felt that having access to the overlearned code would facilitate recall for the syllables presented. The lists were 16 syllables in length and the presentation rate was either .5, 1.0, 1.5, or 2.0 seconds per syllable. The number of syllables recalled was better for both high and low verbal ability groups at the slower rate of presentation and the number recalled decreased as the presentation rate increased. Additionally, the high verbal subjects showed significantly superior recall when the task was enhanced by presenting the syllables in an order that formed an identifiable word. Again, it appeared that highly overlearned codes (the words formed) were more accessible to the high verbal subjects.

In a third experiment (Hunt et al., 1975), an attempt was made to assess high and low verbal subjects' ability to maintain order information without the benefit of any semantic content. The subjects were presented with a string of four letters at a rate of 400 msec. per letter. The four letters were followed by a list of either 1, 6, 12, 24, or 36 digits. The subject was required to speak the name of each digit as it appeared and this naming task was inserted to interrupt the potential for rehearsal. After naming the digits, the subject's task was to recall the previously presented list of letters, in order. Errors in responding could be of two types: transposition errors (correct letter, out of sequence) or nontransposition errors (letter reported was not shown in list). The findings indicated that the high verbal subjects made fewer errors of both types, regardless of the amount of interfering material. The number of nontranspositional errors increased as the amount of interfering material increased. The results suggest that high verbal subjects are more sensitive to order information, independent of the semantic content of the material.

The results of the Hunt et al. (1975) studies indicate that high verbal subjects have increased speed of access to highly overlearned codes (such as letters or words) and that high verbal subjects are more sensitive to the order of presentation of material independent of any semantic information involved. Hunt et al. (1975) concluded that a verbal intelligence test can provide a measure of how well an individual can rapidly code and manipulate verbal stimuli.

In a related area of research, Mason (1978) investigated the speed with which highly skilled and less skilled college readers (a measure comparable to high and low verbal ability) access word names from long-term memory. She used two types of stimuli: "regular" words, which confirm to the phonological rules of the language and "exception" words, which do not conform and thus would require a direct visual access to the lexicon for naming. Exception words cannot be phonologically recoded and then be pronounced according to the basic spelling-to-sound rules of the English language. Mason (1978) also mixed the type case that a word was presented in to further disrupt a direct visual access for the words presented in that way.

In Mason's (1978) research, groups of highly skilled and less skilled readers were identified. There was a minimum requirement that the less skilled readers be functioning at least at a mid-eighth grade level. Each subject was presented with lists comprised of 40 "regular" words and 40 "exception" words. Each of these words was presented in either lower case or in mixed case. The words were blocked into groups of 10 by case and by the regular versus exception variable. The subject was informed whether the upcoming list would be of mixed or lower case. The measure of performance was the time elapsed from the presentation of a word until it was named. Mason's (1978) finding was that less skilled readers were slower and made more errors in naming both "exception" and "regular" tupes of words. She also found that the highly skilled readers' error rates did not increase when the words were presented in mixed case.

A second experiment conducted by Mason (1978) involved the inclusion of a two-second latency period following presentation of the word before a response was signaled. This was intended to remove the motor-articulatory factors of the vocalization latency task and to thus rule out the possibility that the less skilled readers were slower in initiating the vocal response. Even with that factor removed, highly skilled readers still responded more quickly than less skilled readers.

Mason (1978) also used single letter spatial frequency in investigating how words and nonwords are named. Spatial frequency refers to the orthographic regularity of the English language. There is considerable constraint in English words as to which letters may occur in which serial position within the word. For example, in a six-letter word, the letter Y frequently occurs in the sixth position but infrequently occurs in the first position. It would be the opposite for a letter such as B or P. Summed spatial frequency was included as a variable of orthographic regularity that has been shown to affect the formation of visual codes. Nonwords, again, would not have a lexical representation and must be phonologically recoded in order to go from print to sound. If words and nonwords seem to be similarly affected by the variable of spatial frequency, then the hypothesis would be that they both are converted from print to sound by phonological recoding rather than direct access to the lexicon for words. The list presented consisted of 160 stimuli. In the list, half were words and half were nonwords. Additionally, half of each of these were four letters long and half were six letters long. Also, half of all the stimuli were high in spatial redundancy and half were low spatial redundancy. The subject was instructed to say the word or nonword as quickly as possible and the vocalization latency was recorded.

Mason's findings (1978) were that nonwords took longer to name than words. Additionally, the less skilled readers were slower than highly skilled readers in naming nonwords. This suggests differences between those two groups beyond simply their ability to use lexical access. It was also suggested that neither group retrieved the pronounciation of words by phonological recoding. The variables of array length, spatial frequency, and number of syllables all influenced the pronounciation latency of words and nonwords.

Specifically, the naming time was longer for two syllable presentations than for one syllable presentations; the naming time was longer for six letter presentations than for four letter presentations; and the naming time was longer for low spatial frequency presentations than for high spatial frequency presentations. Generally, Mason's data were consistent with the theory that visually presented words are pronounced by accessing the lexicon and that within the lexicon there is a program for pronouncing the word.

In an additional approach, Mason (1978) found that by giving two seconds initial presentation of the word or nonword from the previous experiment before the response was cued, reading ability no longer appeared as a significant variable. However, by using scores from which pure vocalization latencies had been subtracted, several factors were found to be significant. Using the adjusted means, the less skilled reader group did demonstrate slower response latencies. The less skilled readers were also more disadvantaged by the addition of two more letters to the task and performed more slowly than the high verbal group. Also, high spatial redundancy resulted in faster vocalization latencies than low spatial redundancy only for nonwords. Mason (1978) felt that spatial redundancy was a visual component of a word that would affect the rate at which letters are recognized and overall word decoding abilities. Skilled readers seemed to be better able to make use of the orthographic regularity of words.

Following her series of research projects, Mason (1978) concluded that less skilled college readers are slower than highly skilled readers in decoding all but short length, high frequency words. She further concluded that although the names of words are not normally derived by phonological recoding, when it becomes necessary to make use of this technique, the low reading ability subjects were at more of a disadvantage than the highly skilled readers.

Hunt, Davidson, and Lansman (1981) examined the relationship of verbal ability and the ability to make categorical judgments. Generally, their intention was to demonstrate an additional measure of speed of access to overlearned information that was related to verbal ability. The semantic categorization part of the experiment consisted of the presentation of a category name (e.g., four-legged animals) followed by a category examplar. Each item consisted of either a drawing of an object or a corresponding word. Twelve of the items were examples of the category and 12 were not. Additionally, of the positive items (those being within the category) there were three high taxonomic and three low taxonomic frequency items and each of these was presented once as a picture and once as a word. Subjects were requested to press either of two keys, as quickly as possible, to indicate whether the example was a member of the category. Verbal ability was measured by the Nelson-Denny Reading test.

A second verbal task was presented as a true-false paper and pencil task. A subject was given three sections of 64 items. There were 16 possible descriptive sentences that were matched with either of two pictures. The two pictures were one of a star with a plus underneath and one with a plus with a star underneath. The sentences (e.g., plus above star; star isn't above plus) either described or did not describe the accompanying picture and the subject responded either true or false. Subjects were given a maximum of 2.5 minutes to complete each section. The inclusion of this task was to provide a verbal task that depended less on access to the meaning of words and more on the manipulation of verbal items in working memory.

A third part to the experiment involved three separate tasks. The first required the subject to determine whether two words presented had the same name or not. Subjects were presented with 24 physically identical pairs (DATE-DATE), 24 same name pairs (DATE-date), and 48 different pairs (date-gate) with each pair shown twice. The word pairs were presented either simultaneously on the screen or sequentially (the first word for 500 msec. followed by the second word 1500 msec. later). Subjects were also given simultaneous and sequential versions of the previously mentioned semantic categorization task. In the simultaneous condition, a category name and item were presented together and the response remained a decision as to whether the item was an example of the category. In the sequential condition, the category name appeared first for each trial, followed by the item. The final task was semantic matching in which two items were presented and the subject had to decide whether or not they were members of the same category. The items were presented either simultaneously or sequentially. The dependent variable was the reaction time for making the required decision.

The data indicated that positive decisions were made faster than negative, high frequency examples were identified faster than low frequency examples, and pictures were identified faster than words. Overall, Hunt et al. (1981) concluded that there does appear to be a relationship between faster category identification ability and their measure of verbal ability. The experimental manipulation of presenting the items sequentially (causing more short-term memory demands) or simultaneously did not significantly change the reaction time latency factor in its relation to verbal ability. Hunt et al. (1981) noted that each of the tasks used required the subject to access semantic or lexical information from long-term memory. A factor analysis approach to the data suggested that all the different memory access tasks tap a single common factor and this factor is positively (although only moderately significant) related to their verbal ability measures of reading and vocabulary.

Goldberg, Schwartz, and Stewart (1977) found high verbal subjects to be faster than low verbal skill subjects in several word matching tasks which attempted to assess long-term memory retrieval abilities. They studied taxonomic category identity matching, in which the judgment was if the two words presented referred to elements of the same general category. They studied physical identity matching, in which the judgment was if two words were exactly the same in physical appearance. They also studied homophone identity matching in which the judgment was if two words were pronounced exactly the same. In each of these three conditions, the subject was presented with a list of 60 word pairs and was required to make the judgment of the pair being "same" or "different." Within each list, half of the presentations were the same and half were different. The findings were that high verbal ability subjects were faster at making all three types of judgments. Goldberg et al. (1972) concluded that high verbal ability is an important factor in increasing the speed in which tasks are performed which require access to long-term memory information. They also proposed that high verbal ability may also enhance performance on tasks which require access to short-term memory.

Focus of This Research

The purpose of my dissertation research was to re-examine the possible effects of age on lexical access. One variable assessed was the verbal ability of the subjects. Verbal ability has been found to be related to the speed of lexical access (Hunt et al., 1975; Mason, 1978). Age has also been found to be related to the speed of lexical access (Petros et al., 1983). The factors of age and verbal ability should operate in such a way that they work together in affecting a subject's performance. Based on the cognitive slowing hypothesis, an interaction effect was expected such that the performance difference between older and younger adults would be larger for a population of low verbal subjects.

The measure of verbal ability used was the Shipley-Hartford test. This test includes a broader based measure of verbal abilities by including both a vocabulary portion and an abstract verbal reasoning portion. The older population can be compared to the younger adult population for indicators of deterioration in both of the areas involved. This allowed for a better analysis of individual differences. Hartley (1986), in a study of memory for short texts of material, used the Shipley-Hartford scale as a measure of verbal ability. She found that both the vocabulary and the abstract reasoning portions differentiated between old and young subject populations. In her study, the older group of subjects performed better on the vocabulary portion, while the younger group of subjects performed better on the abstract reasoning portion.

A second variable allowed was a more detailed manipulation of word frequency than previously used. Many studies have used only high frequency words (e.g., Erber, 1974) and have felt that this has created a more difficult task in terms of recognition from a list. Additionally, it is noted that Bowles and Poon (1981) and Forster and Chambers (1973) included the use of both high and low usage words as stimuli. The present study divided the words used in the naming task into eight different levels of frequency of usage to allow for more detailed evaluation of the effect that word frequency may have.

The present task involved a naming response to words displayed on a screen. Nebes (1978) reported that vocalization times in responding did not differ with the variable of age, while manual response latencies were longer for the older subject group. Cerella and Fozard (1984) however, did observe a difference in vocalization with age. The reaction time control measure was taken both before and after the presentation of the experimental stimuli in an attempt to provide a reliable measure of this component of the response. If present, any inherent differences in vocalization times between young and old adults can be recognized and evaluated separately from the effects of the other subject variables.

A third variable assessed was the subjects' abilities on a block design task. Salthouse (1987) has found age-related differences in both timed measures of performance and efficiency measures of performance on a block design task. Both of these measures were significantly correlated with scores on the Block Design subtest of the Wechsler Adult Intelligence Scale--Revised. Salthouse's block design task was set up to minimize the effects of decreased manual dexterity and slower rate of performance that is seen in older populations. Although the specific task used by Salthouse was not used, the correlation of his measures to the WAIS-R Block Design subtest suggests that it would be a reasonable task itself for comparison purposes.

It was expected that the verbal abilities of a subject would positively affect their ability to perform the naming task and that, overall, high verbal subjects would perform more quickly than low verbal subjects. Additionally, it was expected that the subjects' ability on the block design subtest, as another measure of intelligence, would also positively relate to their ability to perform the naming task. It was expected that the subjects with high block design abilities would perform the naming task with shorter response latencies.

It was also expected that the high frequency words would be responded to more quickly than low frequency words and that this would be observed in decreasing speed of response on the various frequency levels, going from the high frequency word group to the low frequency word group.

This research provided the above-mentioned measures for both older and younger adults and addressed the issue of cognitive slowing as a viable hypothesis for observed decrements in functioning in older subject populations. Additionally, it provided both a verbal and a non-verbal measure of individual differences in intellectual functioning. This allows us to compare these factors as they relate to a lexical access task.

CHAPTER II

METHOD

Subjects

Sixty-four adults comprising both an "older" and a "younger" group served as subjects. The younger adult group of 33 subjects ranged in age from 18 to 35 and was chosen from a pool of undergraduate psychology students at the University of North Dakota. They were reimbursed with extra credit for their courses. The older adult group of 31 subjects ranged in age from 60 to 84. They were recruited by advertisement, were all living independently in some of the larger cities in North Dakota, and were offered $10 as reimbursement for their participation. Differences in gender were not analyzed and previous literature has not suggested such analysis to be pertinent to the present line of research.

Materials

A list of 128 experimental words plus 24 practice words and two sets of 24 reaction time control (RTC) trials were used for the naming task. The experimental words consisted of four to seven letters each and this group was comprised of 16 words at each of eight levels of frequency ranging from low to high. The frequency level of the words was defined according to the frequency tables of Kucera and Francis (1976). The ranges and mean level of frequency for each level of frequency are presented in Table 1. The practice words and RTC words were equally representative of the eight frequency levels. The first set of RTC words presented to each subject was subsequently used as the set of practice words for that subject's experimental trials.

Word lists were presented on an Apple II computer and video monitor. The words were presented one at a time and each trial was cued to begin by the experimenter following the response to the previous trial. The subject's spoken response was picked up by a microphone and triggered a relay switch, which stopped the latency timer. The timing was done by the Apple II and latencies were automatically stored on a disc.

The Block Design blocks and stimulus cards from the Wechsler Adult Intelligence Scale--Revised were used in the administration of that subtest.

Procedure

Each subject was tested individually in a room that was quiet and free from distractions. Demographic information including age, education level, and information on any prescription medication that the participant was currently taking was obtained before the testing session. The subject was administered the Shipley-Hartford (Shipley, 1967) and a maximum of 20 minutes was allowed for that task. That was followed by the administration of the Block Design subtest, according to standardized procedures as set forth in the Wechsler Adult Intelligence Scale--Revised manual (Wechsler, 1981). The

Table 1

Means and Ranges for the Six Levels of Word Frequency*

Frequency Level	Mean	Range
L1	8	1 - 14
L2	20	15 - 25
L3	35	27 - 44
L4	55	47 - 62
L5	73	65 - 84
L6	104	96 - 114
L7	136	119 - 150
L8	260	192 - 348

*The frequency indicates the number of occurrences in Kucera and Francis' (1967) sample of 1,014,232 words.

subject was then administered the Spielberger State Anxiety Scale (Spielberger, Gorsuch, & Lushene, 1968), the Beck Depression Inventory (Beck, 1967), and the Wahler Health Inventory (Wahler, 1983). No time limit was placed on any of those tasks. The subject was then seated facing the video monitor with the microphone placed in front of him. The testing session consisted of presentation of the naming trials along with the appropriate practice trials and RTC trials. The following sequence was followed: 24 reaction time control (RTC) trials, followed by 24 practice trials, followed by 96 experimental trials followed by an additional 24 RTC trials. Within all the practice trials, experimental trials, and RTC trials, the various frequency levels of the words were randomized. The RTC trials consisted of a word being presented on the video monitor for approximately three seconds and the subject responded by naming the word as soon as it disappeared from the screen and was replaced by a string of Xs, for example, "XXXXX." The practice and experimental trials consisted of the presentation of an "X" on the screen for approximately three seconds followed by the appearance of a word. The subject responded by naming the word as quickly as possible.

For the RTC task, the subject was given the following instructions: "I want you to watch the monitor closely. You will be presented with a series of 24 words, one at a time, which I want you to name aloud as quickly as you can as soon as they disappear from the screen. As they disappear they will be replaced by a row of Xs and you are to respond when you see that row." Following this portion of the project, the subject was given a brief rest while the next set of trials was being prepared.

Following the rest period, the subject was given the following instructions: "You will now continue with a new task. During this portion of the project, you will be presented with 120 more words, which I would like you to say aloud as quickly as possible after they appear on the screen. There will be a warning sign of an "X" just before the word will appear. Remember, you are to name the word as quickly as you can after it appears on the screen."

After the experimental trials were run, a second set of 24 RTC trials was run, following the same instructions as with the first set.

CHAPTER III

RESULTS

The median response time was computed in each condition separately for each subject, however response times associated with errors and anticipatory responses were excluded from these calculations. Error rates were also computed for each subject in each condition. Additionally, the scores on the six individual difference measures were examined. Demographic and individual difference data for the groups are presented in Table 2.

Separate one-way analyses of variance were run comparing the young and old subject groups on each of the six individual difference measures. For these measures, the older subjects scored significantly higher than the younger on the Shipley vocabulary test, $F\ (1, 62) = 9.88$, $p = .003$. The younger subjects scored significantly higher than the older on the Shipley abstraction measure, $F\ (1, 62) = 22.14$, $p < .001$, and on the block design task, $F\ (1, 62) = 17.73$, $p < .001$. No significant difference between the two groups was found on the measures of health, $F\ (1, 62) = .022$, $p > .50$; state anxiety, $F\ (1, 62) = 1.56$, $p = .217$; or depression, $F\ (1, 62) = .04$, $p > .50$ (see Table 2).

The median response time was computed at each level of frequency separately for every subject, with response times associated with errors deleted from these computations. A 2 (age) x

Table 2

Individual Difference Data for Young and Old Subjects

	Young		Old	
N	33		31	
Age	mean	21.18	mean	70.52
	sd	3.23	sd	5.89
Years of education	mean	14.00	mean	14.97
	sd	1.10	sd	2.70
Shipley Vocabulary	mean	29.00	mean	32.19
	sd	3.17	sd	4.83
Shipley Abstraction	mean	16.24	mean	12.65
	sd	2.18	sd	3.77
WAIS-R Block Design	mean	35.73	mean	27.19
	sd	8.77	sd	7.32
Wahler	mean	0.70	mean	0.72
	sd	.35	sd	.42
Spielberger	mean	33.82	mean	31.03
	sd	8.60	sd	9.26
Beck	mean	5.06	mean	5.26
	sd	4.76	sd	3.30
SLOPE	mean	-3.93	mean	-3.64
	sd	2.22	sd	2.77

8 (frequency) mixed analysis of variance was computed on this data. Significant main effects of age, $F(1, 62) = 33.294$, $p < .001$, and of frequency, $F(7, 434) = 24.516$, $p < .001$ were found, along with a significant age x frequency interaction, $F(7, 434) = 2.280$, $p = .028$.

The significant effect of age indicated that response latency to the experimental words was longer for the older adults (mean = 620 msec) when compared to the younger adults (mean = 513 msec). The significant effect of frequency level indicated a general pattern of faster response times for more frequently occurring words. These results can be seen in Table 3. The interaction effect, although significant, revealed that the size of the age difference did not increase monotonically nor did it show any interpretable pattern across the different levels of frequency and ranged between 15-19%. These results are presented in Table 3.

The proportion of errors was computed at each level of frequency separately for each subject. These data were analyzed in a 2 (age) x 8 (frequency) mixed analysis of variance. No significant effects were observed in this analysis.

Additionally, the median response time for each subject was computed for RTC1 (trials prior to the experimental trials), RTC2 (trials following the experimental trials), and for RTCAV (the average between the two). This data is presented in the bottom section of Table 3. A one-way ANOVA computed on RTC1 revealed a significant effect of age, $F(1, 62) = 39.71$, $p < .001$. For RTC2, a significant

Table 3

Median Response Latencies as a Function of Age and Frequency Level

Frequency Levels	Young	Old	Difference	%
L1	534.3	636.5	102.2	16
L2	522.5	632.5	110.0	17
L3	511.5	619.4	107.9	17
L4	517.8	623.6	105.8	17
L5	496.9	610.2	113.3	19
L6	522.2	615.6	93.4	15
L7	501.9	617.4	115.5	19
L8	500.3	607.2	106.9	18
Response Time Control Data				
RTC1	398.2	646.3	248.1	38
RTC2	382.3	540.1	157.8	29
AVRTC	390.3	593.2	202.9	34

effect of age also was found, $F(1, 62) = 37.38$, $p < .001$, and for RTCAV a significant effect of age was found, $F(1, 62) = 42.69$, $p < .001$. These results suggest that a significant difference existed between the old and young groups, with the young group being faster on any type of reaction time control measure that was taken.

A 2 (age) x 2 (time of RTC measure) ANOVA was also computed. Significant main effects of age, $F(1, 62) = 42.69$, $p < .001$ and time of measurement, $F(1, 62) = 26.00$, $p < .001$ were found. Additionally, a significant age x time interaction effect was found, $F(1, 62) = 14.25$, $p < .001$. A subsequent analysis of this interaction indicated that the older adults were slower on both RTC measures, but that the difference between the older and younger adults decreased on the second RTC measure taken. In looking at the data in Table 3, it can be seen that the younger adults appear to have improved only slightly from RTC1 to RTC2 while the older adults made a marked improvement in latency of response.

In order to further explore the relationships between the various individual difference variables and age differences in performance, bivariate correlations were computed overall and separately for young and older adults. A simultaneous multiple regression was computed separately for every subject to compute the slope of the line relating frequency to response time. This slope measure is also one of the individual difference variables included in the correlation matrix along with the three different RTC measures. The overall correlation matrix is presented in Appendix A, while a correlation matrix is presented separately for the younger and older groups in Appendices B and C, respectively. It is evident that many of the predictor variables were intercorrelated and that many factors correlate with the dependent variable of reaction time.

Analysis of the previous ANOVA results (see Table 3) suggests that, although the interaction effect of age x frequency level was significant, the size of the difference between the young and old groups seemed to remain fairly constant through the various levels of frequency. These results suggest that the age differences in naming latency cannot be accounted for solely at the lexical access stage and warrant further analysis. Therefore, a number of simultaneous multiple regressions were performed to investigate the contribution that the various individual difference measure factors may have on performance.

A simultaneous multiple regression analysis was conducted on the response time data of the experimental trials. The results are presented in Table 4. This analysis included the RTCAV measure as an estimate of simple vocal response time differences between young and old adults. The average was used to offset the marked improvement that was observed for the older group from RTC1 to RTC2. Table 4 presents the regression coefficients, Beta weights, F values, and R-squared. The regression coefficient indicates the amount of increase or decrease in the dependent variable there is for each unit increase in the independent variable. The Beta weights are standardized regression coefficients that allow comparisons to be made among the various predictors in terms of their relative importance for predicting variance in the dependent variable. In looking

Table 4

Multiple Regression Analysis of Response Latency

Predictor	Coefficient	Beta	F	R-squared
RTCAV	.26	.4462	108.61*	.440
Age	57.26	.3092	41.97*	.040
Vocabulary	-3.56	-.1656	20.57*	.037
Anxiety	-2.03	-.1952	35.36*	.018
Depression	3.00	.1315	15.20*	.019
Frequency	-3.79	-.0938	10.17*	.009
Health	15.93	.0648	3.84*	.003
Education	1.97	.0445	1.81	.001
Block Design	0.20	.0195	0.26	.000
Abstraction	-0.40	-.0151	0.13	.000

* = $p < .05$

at Table 4, it can be seen that a number of variables were able to account for a significant amount of variance of the dependent variable of reaction time. The largest predictor was RTCAV, which accounted for approximately 44% of the variance in reaction time. The next largest predictor was age, which accounted for 3.9% of the variance. It should also be noted that some of the variables had a negative relationship with reaction time. For example, an increase in the vocabulary score was associated with decreased reaction times. Also, as had been observed in the ANOVA, an increase in the frequency level of the word presented was associated with decreased reaction times. It also appeared that an increase on the measure of depression was associated with longer response latencies. Conversely, an increase in the measure of anxiety was associated with shorter response latencies. Another interesting result was that an increase in the score on the measure of health (which indicated more health concerns) was associated with slower reaction times.

A simultaneous multiple regression analysis was also conducted on the error rate of the subjects' performance during the experimental trials. These results are presented in Table 5. As can be seen from the table, only two variables were significant in accounting for the variance observed in these scores. The individual's score on the vocabulary task was negatively related to error rate, such that an increase in vocabulary ability was related to a decrease in error rate. Secondly, age was a significant, although small, factor and an increase in age was related to an increased error rate. As noted, both of these factors did not account for much of the

Table 5

Multiple Regression Analysis of Error Rate

Predictor	Coefficient	Beta	F	R-squared
Vocabulary	-.0014	-.1862	10.84*	.015
Age	.0100	.1544	5.14*	.004
RTCAV	-.00001	.0491	.86	.002
Health	-.0043	-.0054	1.03	.001
Anxiety	.0002	.0550	.88	.001
Education	-.0007	-.0452	.74	.001
Abstraction	.0004	.0433	.41	.001
Depression	.0003	.0376	.62	.001
Frequency	-.0001	.0071	.03	.000
Block Design	.00003	.0084	.02	.000

* = $p < .05$

variance and, as reported previously, the ANOVA on this data did not provide significant results. It also seems worth noting that the word frequency was not a significant factor when analyzing the error rate data. This suggests that although the response times varied with level of frequency, there was no difference in error rates at the various levels.

The third dependent variable analyzed through simultaneous multiple regression was the average reaction time control (RTCAV). These results are presented in Table 6. The variable of age accounted for just over 40% of the variance in RTCAV. This underscores the extreme difference between the young and old populations with respect to their performance on the RTC trials. Furthermore, the variables of Abstraction, Block Design, Vocabulary, and Health were all significant and were all related in a negative direction. This indicates that a higher score on each of these variables in associated with shorter response latencies on the RTCAV measure.

The final dependent variable analyzed through a simultaneous multiple regression procedure was the slope of the line obtained for the reaction times across the levels of word frequency. The median response latencies that formed this slope across the different levels of frequency can be seen in Table 3. The trend was that for each shift to a higher level of frequency, the reaction times decreased approximately 4 milliseconds. In the evaluation of the individual difference variables, several were found to be significant, although the amount of variance that they were able to account for was not large. The variables of Vocabulary and Abstraction

Table 6

Multiple Regression Analysis of RTCAV

Predictor	Coefficient	Beta	F	R-squared
Age	164.60	.5179	138.82*	.408
Abstraction	-7.26	.1602	14.29*	.073
Block Design	-3.82	.2175	32.77*	.025
Vocabulary	-4.60	-.1247	11.01*	.010
Depression	3.55	.0906	6.76*	.006
Health	-34.54	-.0819	5.73*	.004
Education	-4.80	-.0632	3.39	.003
Anxiety	0.47	.0263	0.59	.001
Frequency	0.00	.0000	0.00	.000

* = $p < .05$

were both positively related to the slope. This would indicate that an increase in the independent variable would be associated with an increase in the slope. Since the slopes were negative, a positive change in them would mean a smaller slope and thus a leveling out effect. Thus a positive relationship would suggest smaller slopes related to the Vocabulary and Abstraction variables. A smaller slope suggests more efficient abilities to access material at the various frequency levels and that individuals higher on these two variables would be less subject to the influences of frequency. The results also indicate that the measure of Anxiety showed a positive relationship to slope, thus it could be expected that a more anxious individual would also be less subject to the influences of frequency. The variable of Depression showed a negative relationship and this would suggest higher scores on Depression would be related to a steeper slope across levels of frequency. The results of this analysis are presented in Table 7.

Table 7

Multiple Regression Analysis of Line Slope

Predictor	Coefficient	Beta	F	R-squared
Vocabulary	.15	.2582	25.20*	.089
Anxiety	.05	.1779	15.11*	.025
Depression	-.11	-.1783	15.02*	.024
RTCAV	.002	.1270	3.99*	.009
Abstraction	.11	.1541	7.02*	.008
Health	-.19	-.0286	.41	.001
Block Design	.003	.0108	.05	.000
Age	.03	.0060	.01	.000

* = $p < .05$

CHAPTER IV

DISCUSSION

One major issue addressed by this study is the existence of age-related differences in lexical access. One level of analysis of the present data appears to show that there was not a difference between older and younger adults in the speed and accuracy of accessing lexical information from long-term memory. The effect of word frequency on latency of response basically was the same for both old and young subjects, as could be observed in the similar slopes of reaction time across frequency levels. In previous research, the frequency level of a word was related to the speed of lexical access. Researchers then assumed that if a variable (e.g., age) is related to lexical access speed, that variable should statistically interact with word frequency. However, the present results failed to demonstrate a significant age x frequency effect, which suggests that these two variables are additive in their effects on lexical access speed. Although a statistically significant interaction was found, the size of the age differences was similar at all levels of word frequency. Previous work (Cerella, 1984) suggests that if slower lexical access speed could not be identified as a determining factor in the longer latency of response for older subjects, then it would be reasonable to look at an age-associated difference in basic reaction time as a factor.

One strength of the present study was the large number of levels of the frequency variable used. This provided the strongest manipulation of this variable yet in the literature, as previous work has merely utilized two levels of frequency (high vs. low) (Bowles & Poon, 1981; Forster & Chambers, 1973). Even with a strong manipulation of frequency, the interaction with age was not very clear in the ANOVA procedures.

The present study attempted to measure age differences in simple response time both before and after the experimental trials. A significant difference was found between the young and old groups on the RTC measure and the latency of response was so large for the older group that it could not be used as a correction factor to isolate the specific time for lexical access. Nebes (1978) did not find this difference for vocalization latencies, and the present findings create questions on the ability to use a RTC measure in assessing speed of lexical access, or suggest that this measure must be chosen carefully. It is noted that in Nebes' reaction time measure, the screen was initially blank and the subject was given a verbal cue that the trial was beginning. Following an interval that varied between 1/2 to 2 seconds, a row of Xs appeared on the screen and the subject was to respond by saying a prescribed word (e.g., "yes"). In the present study a different word appeared on the screen for each trial and remained on for 3 seconds. The subject was to say each word as soon as it disappeared and the row of Xs appeared. This created a slightly different, although comparable, task. A difference in the response latencies between older and younger adults seems to remain in the present study that cannot be accounted for by differences in the speed of lexical access.

A subsequent examination of the data using simultaneous multiple regression procedures suggests that age accounts for a significant amount of the variance in response time, even after the variance due to simple motor response time had been accounted for. This would suggest that the age differences could not be accounted for solely by a difference in simple motor performance, although that likely is a major factor. These results suggest that aging affects some component of word recognition other than the lexical access process. Subsequent research needs to examine other variables related to word recognition (e.g., spatial redundancy, age of acquisition, etc.) for their potential interactions with age.

The performance latency of an individual also was influenced by other factors such as vocabulary ability, level of anxiety, level of depression, and the health index for the individual. These results do seem to indicate that the basis of the differences found between older and younger subjects in this research may be quite complicated. Subsequent work needs to more carefully explore the role of individual difference variables as they modulate the size of the age differences observed in performance.

Further analysis through multiple regression was completed in looking at the RTC variable itself. Those results (Table 6) found that age was the major factor in accounting for the variance observed. However, once again, a number of other variables were also found to be significant. These included a negative relationship with the variables of abstraction ability, block design skill, and vocabulary ability. It is interesting to note that there was a relationship between these cognitive abilities and a basic reaction time motor skill. The negative direction of this relationship provides interesting room for discussion. It would seem that the relationship may be such that individuals with better abilities on the more cognitively oriented tasks also seem to be responding with quicker reaction times. This suggests a cognitive element to the motor response which might be a mediating factor in an individual's speed of response. It would also suggest that, as the aging process affects an individual's ability to think it would also affect their ability to react with any required action.

The slower reaction time for older subjects did not seem to involve a more cautious approach to the task. There did not seem to be a speed-accuracy trade-off involved in the slower response times of the older subjects. Overall, the error rates were quite low for both age groups at all levels of frequency. This would be consistent with the findings of Bowles and Poon (1981) in which the level of accuracy was found to be quite similar between older and younger populations. It is also noted that in the multiple regression analysis of the error rate, the RTC variable, which would be an indicator of speed of response, was not a significant predictor of variance. It does not appear that the quicker response times observed were at the expense of accuracy. This issue has been brought up in previous research (Perlmutter, 1978) which led the researchers to postulate that the older subjects may have been taking a different approach to the task at hand and that their performance was hampered by the approach taken. Additionally, there may have been some type of decision making involved (Eysenck, 1975) which may have been particularly a factor in the RTC tasks, which had the effect of slowing the response latency for the older subjects. For this research, it would be quite difficult to ascertain any influences in that area.

One shortcoming of this research is the inability to use the RTC measure as a means of isolating the speed of lexical access. It had been hoped that, by using the "subtraction" method (similar to Cerella and Fozard, 1984) of isolating different levels of processing, a distinct measure of lexical access time could be obtained. Although this was not the case, there were some meaningful results that do confirm age-related differences in performance. However this does leave some question as to the supposition that the age differences lie in the lexical access stage. It is also noted that Thomas et al. (1977) found response latencies to decrease across trials which suggests a possible practice effect. This may explain some of the difference observed in comparing RTC1 with RTC2.

It would be useful for future research to continue to examine lexical access from a variety of methods in hopes of identifying the range of components that it may encompass. Obviously, the present measures seemed to involve more than simple lexical access. By giving the subject 3 seconds to access the word and then responding on cue, it was hoped that the access time could be removed. It was found, however, that some of these reaction times were actually slower than reaction times when the subject was required to access the lexicon and then respond. This points to the inadequacy of this type of RTC but also raises the question of what other factors may be operating in the process.

Certain individual differences in abilities such as vocabulary, perceptual motor skill, and more emotional measures appeared to be related to the subject's ability to perform the task. The individual difference data indicated that the older adults scored significantly higher on the vocabulary measure and that the younger adults scored significantly higher on the verbal abstraction and block design measures. These results are consistent with previous research (Hartley, 1986; Salthouse, 1987). There did not appear to be significant differences between groups on the anxiety, depression, and health measures. This finding would seem to rule out the possibility of any of these factors confounding the age differences observed. In the overall pooling of how these factors may specifically affect response latency, higher abilities on vocabulary and higher anxiety levels were associated with shorter response latencies. Higher levels of depression and more health concerns were associated with longer response latencies. Some previous research (Dixon et al., 1984) had found verbal ability to be a meaningful factor, while other research (Zelinski et al., 1984) had not. Previous research looking at the effects of anxiety (Mueller et al., 1980b) was contradictory to the present findings and suggested that higher levels of anxiety were related to longer latency of response. However, those measures were only taken on the younger subject group. It does appear that there are individual difference characteristics, including vocabulary ability, that can have an influence on performance and are worth accounting for in future research.

In summary and in answer to the purposes stated for this research, lexical access speed does not seem to slow with age. Verbal ability, as measured by a vocabulary task, does seem to affect the latency of response of a subject. The frequency level of a word does have an affect on the response latency, with higher frequency words being responded to with a shorter latency. Contrary to what had been expected, the individual's ability on the block design subtest was not related to latency of response. Also, the other variables measured (anxiety, depression, and health) seemed to have a meaningful enough effect to make them worthwhile in pursuing in future research. It was also found that the frequency level of a word seems to affect both young and old in a similar manner. However, the results also suggest that adult age differences in the speed of naming performance can not be solely accounted for on the basis of age differences in simple motor response time. Some component of word recognition other than lexical access must be sensitive to adult aging. Overall, the present research is viewed as being in support of Salthouse's theory (1980) that views a slower speed of mental operations as a factor in aging. This is not to say that slower operations account for memory problems per se but that it can be a factor in tasks requiring some use of memory.

The importance of these findings lies in their contribution to the various approaches directed towards localizing a specific process or grouping of processes that may deteriorate normally with age. It would appear that certain knowledge of words remains fairly intact and accessible. From a clinical perspective, it would be seen as encouraging that elderly adults are not likely to lose their vocabulary abilities and, although they may not seem as quick to respond as younger adults, the potential is there, depending on the demands of the situation. The speed of the lexical access portion of any cognitive demand seems to remain intact and would thus suggest a certain amount of specificity to any deterioration that may take place.

APPENDIX A

CORRELATION MATRIX FOR INDIVIDUAL DIFFERENCE AND RESPONSE MEASURES--COMBINED YOUNGER AND OLDER GROUP DATA

Table 8

Correlation Matrix for Individual Difference and Response Measures--Combined Younger and Older Group Data

	VOC	ABST	B.D.	HEALTH	ANX	BECK	AGE	SLOPE	RTC1	RTC2	AV	ED	AGE YEARS	RT	FQ
VOC		.077	-.109*	-.152*	.119*	-.011	.371*	.299*	.069	.068	.071	.353*	.405*	-.041	0
ABST			.527*	-.118*	.009	-.202*	.512*	.150*	-.530*	-.566*	-.560*	.026	-.503*	-.462*	0
B.D.				-.045	-.008	.004	-.472*	-.001	-.499*	-.516*	-.521*	-.134*	-.488*	-.356*	0
HEALTH					.202*	.349*	.018	-.110*	-.015	.091*	.027	-.244*	-.032	.105*	0
ANX						.284*	-.156*	.142*	-.105*	.008	-.063	.038	-.144*	-.239*	0
BECK							.024	-.159*	.097*	.161*	.126*	-.173*	.028	.160*	0
AGE								.058	.625*	.613*	.639*	.231*	.982*	.577*	0
SLOPE									-.022	.038	.014	.087*	.086	-.309*	0
RTC1										.882*	.982*	.053	.677*	.657*	0
RTC2											.956*	.024	.669*	.625*	0
AV												.043	.694*	.664*	0
ED													.280*	.028	0
AGE YEARS														.599*	0
RT															-.094*
FQ															

* = p < .05

APPENDIX B

CORRELATION MATRIX FOR INDIVIDUAL DIFFERENCE AND

RESPONSE MEASURES--OLDER GROUP DATA

Table 9

Correlation Matrix for Individual Difference and Response Measures--Older Group Data

	VOC	ABST	B.D.	HEALTH	ANX	BECK	SLOPE	RTC1	RTC2	AV	ED	AGE YEARS	RT	FQ
VOC		.457*	.147*	-.407*	.159*	-.487*	.482*	-.246*	-.247*	-.253*	.363*	.361*	-.356*	0
ABST			.465*	-.155*	-.097	-.386*	.334*	-.378*	-.487*	-.432*	.225*	.045	-.319*	0
B.D.				.157*	-.455*	-.126*	.003	-.419*	-.433*	-.436*	-.074	-.311*	-.045	0
HEALTH					.158*	.416*	-.144	.028	.101	.058	-.315*	-.294*	.216	0
ANX						.072	.342*	.036	.211*	.107	.205*	.210*	-.287*	0
BECK							-.127*	.311*	.337*	.330*	-.331*	.101	.390*	0
SLOPE								-.057	-.025	-.046	.200*	.279*	-.534*	0
RTC1									.885*	.983*	-.156*	.479*	.465*	0
RTC2										.955*	-.164*	.472*	.401*	0
AV											-.164*	.490*	.453*	0
ED												.262*	-.191*	0
AGE YEARS													.135*	0
RT														-.087
FQ														

* = $p < .05$

APPENDIX C

CORRELATION MATRIX FOR INDIVIDUAL DIFFERENCE AND RESPONSE MEASURES--YOUNGER GROUP DATA

Table 10

Correlation Matrix for Individual Difference and Response Measures--Younger Group Data

	VOC	ABST	B.D.	HEALTH	ANX	BECK	SLOPE	RTC1	RTC2	AV	ED	AGE YEARS	RT	FQ
VOC		.036	.009	.228*	.253*	.434*	-.024	-.170*	-.137*	-.183*	.088	-.084	-.291*	0
ABST			.316*	-.078	-.069	-.086	-.036	-.048	.014	-.023	-.026	-.116	.021	0
B.D.				-.228*	.209*	.095	.058	-.184*	-.237*	-.246*	.048	.059	-.247*	0
HEALTH					.267*	.320*	-.106	-.236*	.112	-.092	-.140*	-.219*	-.092	0
ANX						.456*	-.083	-.142*	-.011	-.097	-.221*	-.227*	-.007	0
BECK							-.201*	-.197*	.045	-.102	-.041	-.069	-.032	0
SLOPE								-.034	.069	.015	-.268*	-.104	-.194*	0
RTC1									.429*	.874*	.108	.247*	.494*	0
RTC2										.814*	-.106	.364*	.494*	0
AV											.012	.354*	.583*	0
ED												.427*	.117	0
AGE YEARS													.444*	0
RT														-.180
FQ														

* = $p < .05$

APPENDIX D

LIST OF EXPERIMENTAL STIMULUS WORDS

LIST OF EXPERIMENTAL STIMULUS WORDS

BODY
MIGHT
METAL
SHIRT
WEATHER
CHICKEN
ROBIN
YARD
THREAD
PENCIL
VALUE
BAND
CONTROL
POISON
MONEY
DATE
SEASON
CUBE
PART
TRIP
UNION
STATION
PASTURE
DANGER
TROUBLE
MINUTE
LETTER
TYPE
RESULT
DOZEN
TRIUMPH
EXTREME
MOTHER
LAWYER
FASHION
LAND
SCIENCE
ADVICE
PRIMARY
SNAKE
SAND
DIGNITY
SQUARE

CAUSE
SILENCE
HISTORY
PARDON
MILE
LINE
ORDER
RATE
PYRAMID
BRAIN
MARCH
FLAG
DESIGN
GAME
PLANET
SERVANT
BACK
LEADER
WASTE
SOUND
HOTEL
DISPLAY
NATION
FIND
WOMAN
UNIT
TAPE
STABLE
BROTHER
WATER
FURNACE
BEDROOM
REST
HEALTH
BRICK
PERIOD
PATTERN
NOTICE
SHAPE
PACKAGE
WHOLE
COMPANY
DRINK

DEAL
FACTOR
INSECT
STUDENT
CHAPEL
LATCH
SPACE
PARK
BARN
ARMY
LAUNDRY
STEAM
CHAIN
NORMAL
WINTER
PROTEST
EDGE
STYLE
BRANCH
INCOME
CONCERN
SMOKE
GARDEN
ORANGE
TEACHER
RAIN
CHURCH
CENTURY
VICTORY
ROAD
CAGE
BLANKET
FIGHT
GIRL
HEART
COAT
HOLD
PIGEON
VOICE
PLACE
HOME
PURPOSE

APPENDIX E

LIST OF REACTION TIME CONTROL STIMULUS WORDS

LIST OF REACTION TIME CONTROL STIMULUS WORDS

RTC1	RTC2
MALE	BASE
CAPITAL	COUSIN
FORM	EIGHT
FORCE	DEBATE
DELIGHT	LUNCH
CREW	STEP
RESPECT	FRUIT
WINDOW	CASE
GUARD	BORDER
HUNTER	FEELING
TRAIL	MUSIC
METHOD	YEAR
JUNIOR	BLADE
HOSE	UNIFORM
SECOND	CAVERN
HUMAN	EVENING
SIGNAL	COUNTRY
RANGE	ANIMAL
COLD	WEST
SURFACE	WAND
MINERAL	REASON
FORTUNE	CABINET
FROST	MARKET
CENT	COSTUME

APPENDIX F

SUMMARY ANOVA TABLE FOR MEDIAN RESPONSE TIME

Table 11

Summary ANOVA Table for Median Response Time

Source	Sum of Squares	Df	Mean Squares	F-test	P
Age	1460329.00	1	1460329.00	33.29	.001
Unit	2719416.00	62	43861.55		
Frequency	56296.37	7	8042.34	24.52	.001
Age x Frequency	5236.20	7	748.03	2.28	.028
Frequency x Unit	142369.00	434	328.04		
Total	4383646.00	511	8578.56		

APPENDIX G

SUMMARY ANOVA TABLE FOR ERROR RATE

Table 12

Summary ANOVA Table for Error Rate

Source	Sum of Squares	Df	Mean Square	F-test	P
Age	.000	1	.000	.088	.500
Unit	.097	62	.002		
Frequency	.013	7	.002	1.878	.072
Age x Frequency	.004	7	.001	.629	.500
Frequency x Unit	.424	434	.001		
Total	.539	511	.001		

APPENDIX H

SUMMARY OF ONE-WAY ANOVAS FOR INDIVIDUAL

DIFFERENCE MEASURES

Table 13

Summary of One Way ANOVAs for Individual Difference Measures

Measure	Source	Sum of Squares	Df	Mean Square	F-test	P
Shipley Vocabulary	Age	163.02	1	163.02	9.88	.003
	Unit	1022.84	62	16.50		
	Total	1185.86	63	18.82		
Shipley Abstract	Age	206.84	1	206.84	22.143	.001
	Unit	579.16	62	9.34		
	Total	786.00	63	12.48		
Block Design	Age	1164.05	1	1164.05	17.73	.001
	Unit	4071.39	62	65.67		
	Total	5235.44	63	83.10		
Wahler Health	Age	.003	1	.003	.022	.500
	Unit	9.237	62	.149		
	Total	9.241	63	.149		
Spielberger Anxiety	Age	124.06	1	124.06	1.56	.217
	Unit	4941.88	62	79.71		
	Total	5065.94	63	80.41		
Beck Depression	Age	.62	1	.62	.04	.500
	Unit	1051.81	62	16.97		
	Total	1052.44	63	16.71		

APPENDIX I

SUMMARY ANOVA TABLE FOR RTC MEASURES

Table 14

Summary ANOVA Table for RTC Measures

Source	Sum of Squares	Df	Mean Square	F-test	P
Age	1316472.00	1	1316472.00	42.69	.001
Unit	1912048.00	62	30839.48		
Time of RTC Measure	119130.06	1	119130.06	26.00	.001
Age x Time	65258.99	1	65258.99	14.25	.001
Time x Unit	284039.31	62	4581.28		
Total	3696947.00	127	29109.82		

REFERENCES

Arenberg, D. (1976). The effects of input condition on free recall in young and old adults. Journal of Gerontology, 31(5), 551-555.

Arenberg, D., & Robertson-Tchabo, K. W. (1977). Learning and aging. In J. E. Birren & K. W. Schale (Eds.), Handbook of the psychology of aging (pp. 421-449). New York: Van Nostrand Reinhold Company.

Beck, A. T. (1967). Depression: Clinical, experimental, and theoretical aspects. New York: Harper & Row.

Birren, J. E. (197 4). Translations in gerontology: From lab to life. American Psychologist, , 808-815.

Botwinick, J. (1984). Aging and behavior. New York: Springer Publishing.

Bowles, N. L., & Poon, L. W. (1981). The effects of age on speed of lexical access. Experimental Aging Research, 7(4), 417-425.

Brodie, D. A., & Prytulak, L. S. (1975). Free recall curves: Nothing but rehearsing some items more or recalling them sooner? Journal of Verbal Learning and Verbal Behavior, 14, 549-563.

Brown, A. L., & Smiley, S. S. (1977). Rating the importance of structural units of prose passages: A problem of metacognitive development. Child Development, 48, 1-8.

Burke, D. M., & Light, L. L. (1981). Memory and aging: The role of retrieval processes. Psychological Bulletin, 90(3), 513-546.

Byrd, M. (1984). Age differences in the retrieval of information from semantic memory. Experimental Aging Research, 10(1), 29-33.

Cerella, J., & Fozard, J. L. (1984). Lexical access and age. Developmental Psychology, 20(2), 235-243.

Craik, F. I. M., & Simon, E. (1980). Age differences in memory: The roles of attention and depth of processing. In L. W. Poon, J. L. Fozard, L. S. Cermak, D. Arenberg, and L. W. Thompson (Eds.), New directions in memory and aging (pp. 95-112). Hillsdale, NJ: L. Erlbaum Associates.

Dixon, R. A., Hultsch, D. F., Simon, E. W., & von Eye, A. (1984). Verbal ability and text structure effects on adult age differences in text recall. Journal of Verbal Learning and Verbal Behavior, 23(5), 569-578.

Dixon, R. A., Simon, E. W., Nowak, C. A., & Hultsch, D. F. (1982). The recall in adulthood as a function of level of information, input modality, and delay interval. Journal of Gerontology, 37(3), 358-364.

Erber, J. T. (1974). Age differences in recognition memory. Journal of Gerontology, 29(2), 177-181.

Eysenck, M. W. (1975). Retrieval from semantic memory as a function of age. Journal of Gerontology, 30(2), 174-180.

Forster, K. I., & Chambers, S. M. (1973). Lexical access and naming time. Journal of Verbal Learning and Verbal Behavior, 12, 627-635.

Goldberg, R. A., Schwartz, S., & Stewart, M. (1977). Individual differences in cognition processes. Journal of Educational Psychology, 69(1), 9-14.

Hartley, J. T. (1986). Reader and text variables as determinants of discourse memory in adulthood. Psychology and Aging, 1(2), 150-158.

Hultsch, D. F. (1975). Adult age differences in retrieval: Trace-dependent and cue-dependent forgetting. Developmental Psychology, 11(2), 197-201.

Hunt, E. B., Davidson, J., & Lansman, M. (1981). Individual differences in long-term memory access. Memory and Cognition, 9(6), 599-608.

Hunt, E. B., Lunneborg, C., & Lewis, J. (1975). What does it mean to be high verbal? Cognitive Psychology, 7, 194-227.

Kucera, H., & Francis, W. N. (1967). Computational analysis of present day American English. Providence, RI: Brown University Press.

Madden, D. J. (1985). Age-related slowing in the retrieval of information from long-term memory. Journal of Gerontology, 40(2), 208-210.

Mason, M. (1978). From print to sound in mature readers as a function of reader ability and two forms of orthographic regularity. Memory and Cognition, 6(5), 568-581.

Meyer, B. J. F., & Rice, G. E. (1981). Information recalled from prose by young, middle, and old adult readers. Experimental Aging Research, 7, 253-268.

Mueller, J. H., Kausler, D. H., & Faherty, A. (1980). Age and access time for different memory codes. Experimental Aging Research, 6(5), 445-449.

Mueller, J. H., Kausler, D. H., Faherty, A., & Oliveri, M. (1980). Reaction time as a function of age, anxiety, and typicality. Bulletin of the Psychonomic Society, 16(6), 473-476.

Nebes, R. D. (1978). Vocal versus manual response as a determinant of age difference in simple reaction time. Journal of Gerontology, 33(6), 884-889.

Perlmutter, M. (1978). What is aging the aging of? Developmental Psychology, 14(4), 330-345.

Petros, T., Tabor, L., Cooney, T., & Chabot, R. J. (1983). Adult age differences in sensitivity to semantic structure of prose. Developmental Psychology, 19(6), 907-914.

Petros, T., Zehr, H. D., & Chabot, R. J. (1983). Adult age differences in accessing and retrieving information from long-term memory. Journal of Gerontology, 38(5), 589-592.

Raymond, B. J. (1971). Free recall among the aged. Psychological Reports, 29, 1179-1182.

Salthouse, T. A. (1980). Age and memory: Strategies for localizing the loss. In L. W. Poon, J. L. Fozard, L. S. Cermak, D. Arenberg, & L. W. Thompson (Eds.), New directions in memory and aging (pp. 47-65). Hillsdale, NJ: Lawrence Erlbaum Associates, Inc.

Salthouse, T. A. (1982). Adult cognition. New York: Springer-Verlag.

Salthouse, T. A. (1987). Sources of age-related individual differences in block design tests. Intelligence, 11, 245-262.

Schonfield, D., & Robertson, B. (1966). Memory, storage, and aging. Canadian Journal of Psychology, 20(2), 228-236.

Shipley, W. C. (1967). Shipley institute of living scale. Los Angeles: Western Psychological Services.

Smith, A. D. (1977). Adult age differences in cued recall. Developmental Psychology, 13(4), 326-331.

Smith, A. D. (1979). The interaction between age and list length in free recall. Journal of Gerontology, 34(3), 381-387.

Spielberger, C. D., Gorsuch, R. L., & Lushene, R. E. (1968). The state-trait anxiety inventory. Palo Alto: Consulting Psychologists Press.

Thomas, J. C., Fozard, J. L., & Waugh, N. C. (1977). Age-related differences in naming latency. American Journal of Psychology, 90(3), 499-509.

Wahler, H. J. (1983). Wahler physical symptoms inventory manual. Los Angeles: Western Psychological Services.

Waugh, N. C., & Barr, R. A. (1980). Memory and mental tempo. In L. W. Poon, J. L. Fozard, L. S. Cermak, D. Arenberg,, & L. W. Thompson (Eds.), New directions in memory and aging (pp. 251-260). Hillsdale, NJ: Lawrence Erlbaum Associates, Inc.

Waugh, N. C., Thomas, J. C., & Fozard, J. L. (1978). Retrieval time from different memory stores. Journal of Gerontology, 33(5), 718-724.

Wechsler, D. (1981). Manual for the Wechsler adult intelligence scale--revised. New York: The Psychological Corporation.

Wright, R. E. (1982). Adult age similarities in free recall output order and strategies. Journal of Gerontology, 37(1), 76-79.

Zelinski, E. M., Light, L. L., & Gilewski, M. J. (1984). Adult age differences in memory for prose: The question of sensitivity to passage structure. Developmental Psychology, 20(6), 1181-1192.