SHORT - TERM MEMORY PROCESSING OF READING DISABLED AND NORMAL CHILDREN

by

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CHAPTER I

INTRODUCTION

A great many children with near average or above intelligence have difficulty learning to read despite exposure to teaching methods which have been successful with a large majority of students. Estimates of the occurrence of reading problems range from 10 to 30 percent of the school aged population (Austin, Bush and Huebner, 1961; Harris, 1964). A variety of instructional materials and reading methods are available, however the research comparing these materials and methods has failed to identify any specific approach as superior for all children (Bond and Dykstra, 1967).

Educators argue that research has not matched reading approaches to students' learning styles and cannot expect to find significant differences among reading approaches. Instead, they suggest that because of the interaction between learning styles and methods, remedial approaches should be based upon a child - study approach (Bateman, 1967).

Attempts to develop procedures for matching reading instruction to learning characteristics and then comparing reading achievement among approaches also have generally failed to provide insight into the problems of teaching reading. Most attempts to match reading instruction with learning characteristics have used a variety of auditory and visual perception tests. From results of these tests, children are labeled "visual learners" or "auditory learners" and are given reading instruction accordingly (Wolpert, 1971). The Illinois Test of Psycholinguistic Abilities (ITPA) for example, provides a method of identifying a student's strengths and weaknesses in both receptive and responsive modes.

According to the ITPA model there are certain input systems for information and output systems for responding, i.e., information may be received auditorily and responded to verbally, or it may be received visually and responded to motorically. Wepman (1967) refers to these input systems as modalities or pathways of learning. He noted that children are of certain learning types and educators need to determine if the child learns best by "ear or by eye." Like Wepman, Harris (1964) suggested that educators should utilize methods which allow each student to learn by procedures which compliment his particular strengths in perception, imagery and recall. Thus, if the child's strength is in the auditory - verbal channel a phonetic or linguistic approach for teaching reading would be used. On the other hand, if a child has a basic strength in the visual - motor channel, his visual strength would be emphasized through the use of a whole word or sight word approach in the teaching of reading.

A number of studies investigated the modality concept as a valid construct to view learning styles (Mills, 1956; Katz and Deutsch, 1964; Harris, 1965; Bateman, 1967b; Wolpert, 1970; Bruininks, 1970; Tyler, 1971). None of these studies, however, supported the "modality approach" in matching materials to students' learning styles. Despite the absence of research support, a number of writers contend that teaching procedures should be prescribed in accordance with the student's individual learning styles (Durrell and Murphy, 1953; Kirk, 1962; Cohn, 1964; Goldstein, 1964; McCarthy, 1964; Frostig, 1965; de Hirsch, Jansky and Langford, 1966; Neville, 1966; Johnson and Myklebust, 1967; Bateman, 1967a; Bannatyne, 1968; Smith, 1968; Wepman, 1968; Denison, 1968-69).

Educators will continue debating the efficacy of a wide variety of reading approaches, publishers will continue developing reading materials and a large number of children will most likely continue to be poor readers unless the research begins to identify relevant variables which can be translated into remedial programs. An alternate research approach is to focus upon deficits in subskills essential to reading and to explore training programs to eliminate these deficits.

Short - term memory (STM) is one subskill which has been identified as a significant variable in learning to read (Betts, 1950; Rudisill, 1956; Johnson, 1957; Rose, 1958; Alwitt, 1963; Birch and Belmont, 1964; Muehl and Kremenak, 1966; Beery, 1967; Johnson and Myklebust, 1967; Harris, 1970). In a review of the research utilizing subtests of the Wechsler Intelligence Scale for Children and the ITPA Neville (1966) noted that STM was consistently found to be related to poor reading ability. Despite the limitations noted in a review of factors related to reading disability Johnson (1957) similarly concluded that STM deficiencies have a serious effect upon reading achievement. The author stated:

> It would appear from the available evidence, that inadequate memory span, in itself, can be a causative factor in reading disability . . . retarded readers are characterized by a tendency toward certain patterns or relative achievement on tests of memory span with varying test material and modes of presentation [p. 13].

While Johnson cites STM as a causative factor of reading problems she does not discuss variables which may affect STM. A number of variables have been identified which are generally accepted as having an effect on STM. The variables include: amount of practice; pronounceability; recodability, familiarity of items; number of items previously learned; meaningfulness of units; and duration of time between stimulus presentation and responses (Blankenship, 1938; Van deMoortel, 1965; Scott and Scott, 1968). There is, however, little information about the learning strategies people employ which enable them to remember (Chalfant and Scheffelin, 1969).

If STM deficits can be a causative factor in reading disability, as suggested by Rudisill (1956), Rose (1958), Alwitt (1963), Birch and Belmont (1964), Muehl and Kremenak (1966), and Beery (1967), then an extensive examination of variables which contribute to STM deficits and remedial procedures needs to be devised. The STM model proposed by Belmont and Butterfield (1969) has the potential of not only studying STM performance but also providing a rationale for investigating learning strategies employed by reading disabled youngsters in acquiring and retrieving information on the STM task. If poor readers employ different acquisition and retrieval strategies, the identification of these strategies may constitute important variables in the STM process which have remedial implications for eliminating STM deficits.

The present study was designed to investigate STM processes of reading disabled subjects (Ss) by comparing them with a group of normal readers. Specifically, the following research questions were examined:

1. Will reading disabled and normal Ss differ significantly on recall accuracy, acquisition strategies, and/or retrieval processes?

2. Will third, fifth and seventh grade Ss differ significantly on recall accuracy, acquisition strategies, and/or retrieval processes?

3. Will there be significant differences on recall accuracy, acquisition strategies, and/or retrieval processes between: third grade reading disabled and normal Ss, fifth grade reading disabled and normal Ss and seventh grade reading disabled and normal Ss?

The next chapter describes STM models, provides a brief review of a series of studies which have resulted in training strategies to remediate STM deficits in retardates and reviews the STM research which compared reading disabled and normal subjects.

CHAPTER II

REVIEW OF THE LITERATURE

This chapter is divided into four parts. The first part provides a general introduction and brief review of theoretical models of short - term memory (STM) processes. The second part summarizes research on the STM processes in mentally retarded and normal children on a subject - paced, serial learning task. Many of the procedures used in this research are similar to those employed in the present study. The third part summarizes research involving reading disabled students' STM performances on a variety of experimental tasks, and part four provides a discussion and summary of these studies.

Short - term Memory Models

There are numerous models which have been proposed to explain the memory process. However, many of these models utilized a neurological approach and are not functional as educational models for developing remedial procedures for improving STM performance. Neurological views of memory propose that a stimulus is converted into electrical activity (stimulus trace) in the nervous system. The concept of the stimulus trace phenomenon originated from the work of Muller and Pilzecker's (1900) theory of retroactive inhibition. Somewhat later Pavlov (1927) employed the stimulus trace theory to explain trace conditioning in his animal research. More recently, the trace concept had a central role in theoretical constructs of Hebb (1949), Spitz (1963) and Ellis (1963). Most of the neurological approaches emphasized either the dynamic and/or structural approach to memory (Hilgard and Bower, 1966).

In the dynamic approach, memory is the result of continuous electrical activity. Forgetting occurs when the electrical activity discontinues, resulting in the reduction of electrical reverberations necessary to maintain the stimulus trace. In contrast, the structural view of memory suggests that continuous electrical activity and the resulting stimulus trace cannot account for memory unless the electrical circuits change the structural components of the nervous system. The longer the electrical activity continues, the more permanent the structural - physical change and therefore the greater the probability of remembering the stimulus event. Retention is reduced when the stimulus trace is interrupted reducing the physical change in the neural cells (Hilgard and Bower, 1966).

In Hebb's (1949) neurophysiological model of memory, a dual - trace mechanism was proposed which suggested that STM is the result of reverberation of the neuronal circuit. If the neural trace decayed too rapidly, STM is reduced and long - term memory is not possible since the trace decayed before there was a structural change in the neural pathways. Hebb's model therefore uses the dynamic view to explain STM and the structural approach to explain the more permanent, long - term memory.

Spitz (1963) also included both the dynamic and structural view in his neural theory to account for poor STM of retardates. His views are summarized in the following postulates:

Postulate I.
In retardates, it takes longer to induce temporary, as well as permanent, electrical, chemical, and physical changes in stimulated cortical cells.

Postulate II.
Once stimuli induce temporary chemcial and electrical modification of cortical cells, it takes longer for these cells to return to their previous state.

Postulate III.
In retardates, once stimuli induce permanent chemical and/or physical changes in cortical cells, it will be more difficult and take a longer period of time to switch consequent like -- or relatively similar -- stimuli away from these particular cell traces or current patterns so as to form new, or different, traces or patterns.

Postulate IV.
In retardates, there is less spread of electrochemical activity from stimulated cells into the surrounding cortical field [pp. 29 - 30].

According to this theory, a deficiency which appears to result from impaired STM may be due largely to the fact that conformation never reached storage, or reached storage in a disorgānzied state. Information which is organized and stored is more resistant to extinction and interference (Scott and Scott, 1968).

Stimulus trace was also used by Ellis (1963) to account for behavioral differences between normal and mentally defective subjects. This model suggests that subnormal behavior which is dependent on STM is caused by a subnormal functioning central nervous system. Learning deficits in the retardate are due to lack of continuity among events as a result of diminished duration and amplitude of the stimulus trace.

The models suggested by Broadbent (1958), Zeaman and House (1963), Waugh and Norman (1965), Belmont and Butterfield (1969), Sperling (1967), and an updated model by Ellis (1970) do not emphasize the neurological stimulus trace paradigm in describing STM deficits. Instead, selective attention and/or inadequate learning are proposed as the critical elements in their STM models. These models may have greater educational implications since they are not dependent upon neurological constructs.

Broadbent's (1958) model of memory and attention suggests that the brain contains "selective filters" that monitor messages which are either accepted or rejected. Incoming information may be held for seconds in a "short - term store" or S System prior to selective filtering. Information which is accepted passes to a "limited capacity channel" (P System) which provides indefinite storage. Storage in the P System, however, reduces its capacity to store additional information. Information can pass from the P System into either long - term storage or feed back to the short - term store. Information which passes through the feedback loop is rehearsed for later recall. Poor STM is a function of an impaired S System and/or the restricted capacity of the P System which limits the amount of information available. The significant feature of Broadbent's model was the inclusion of rehearsal and attention processes which was lacking from earlier formal models of memory.

The Zeaman and House (1963) attention theory was developed to provide a framework for analysis of learning deficits in retardates. According to this theory, poor learning results from the retardates' non-attention to the relevant dimensions and specific cues associated with the stimulus event preceding learning and memory. Poor learning is attributed to attention rather than memory.

This theory has remedial implications and suggests training approaches may enhance the Ss' learning by " . . . engineering of their attention," [Zeaman and House, 1963, p. 218]. Manipulation of the stimulus to increase the attention value of relevant cues and noticeability of relevant dimensions are examples of education implications which are congruent with this theory. The early training approaches of Montessori (1912), Strauss and Lehtinen (1947), and Fernald (1943) appear to utilize some of the principles suggested by this attention theory. This theory, however, is related to discrimination learning rather than STM.

A multiple memory system was proposed by Waugh and Norman (1965) to explain STM. According to their model, a stimulus first enters the primary memory (PM) system. This system, however, has a limited storage capacity and new items replace old ones which are permanently lost. If items are rehearsed, they may prolong their period in PM and increase the probability of entering into the secondary memory (SM) system. This theory would explain why the last items of a list are recalled more accurately than earlier items. This theory also explains why rehearsal is required for delayed recall.

Most STM research has not systematically studied the effects of rehearsal, however, according to Norman (1969) most agree about its importance. Although Broadbent (1958) mentions rehearsal as a part of the feedback loop of his model, Sperling (1967) was the first to stress the importance of the rehearsal process in his STM model. In this model, rehearsal is viewed as a type of innerspeech which helps retention by transferring information from temporary to more permanent systems.

Ellis' (1970) updated model did not stress the stimulus trace concept but incorporated many of the dimensions described by Broadbent (1958), Waugh and Norman (1965), and Sperling (1967). Ellis' model proposed a dual STM process in both normal and retarded subjects:

> External stimulation is sensed through an attention (A) process and fed directly into the primary memory (PM). PM is viewed as a limited capacity system, capable of retaining only a few items which are quite transient, either as a result of decay with time per se or as a result of interference. Information is being constantly replaced in PM by new information. We assume that older items are lost first. PM is viewed as the most inefficient storage with much information being forgotten . . . . The rehearsal strategy (RS) is viewed as the mechanism transferring information from PM to SM . . . RS involves the focus of attention upon information being lost from PM upon SM . . . . Thus RS is in part of a loop where information is fed back through A and PM . . . . Attention may prove to be a superfluous construct. Rehearsal strategy is a key construct. However, at this stage of analysis, it is poorly defined and is perhaps credited with too many functions [pp. 5-6].

Since most of the STM research used an experimenter paced task, Ss had little opportunity to rehearse between presentation of the items. A number of studies have recently been reported which utilized a subject paced, rather than an experimenter paced, serial learning task which allowed independent observation of differential rehearsal strategies and their relationship to STM (Butterfield and Belmont, 1969; Ellis and Dugas, 1968; Pinkus and Laughery, 1970). These studies support that rehearsal (acquisition strategies) plays an important role in STM performance. In addition, Butterfield, Wambold and Belmont (1972) indicate that retrieval as well as acquisition processes are critical to STM performances. Most models and theories of STM have been concerned primarily with acquisition, storage and retention of information, however, the process of retrieving information has been almost completely ignored in formal models of memory (Norman, 1969).

The research model proposed by Butterfield, Wambold and Belmont (1972) suggests that a breakdown on any three aspects of the STM process could account for poor STM. Poor STM could be a function of imperfect learning, poor retention of learned items or incomplete retrieval of learned items that were retained. They noted that substantial literature supported the conclusion that the mentally retarded do not have a retention deficiency and therefore hypothesized that STM deficiency stems from inadequacies in how material is acquired or stored in memory and/or how information is retrieved from memory storage.

Belmont and Butterfield (1969) devised an experimental task which allows the researcher to explore why subjects are deficient in STM. Not only have they been able to support their theoretical position that deficiencies in acquisition and retrieval processes were related to STM performance, but also this knowledge has been translated into remedial techniques which have resulted in significant improvement of STM of mentally retarded subjects (Butterfield, Wambold and Belmont, 1972).

Acquisition and Retrieval of Retarded and Normal Subjects

A series of studies were completed to experimentally evaluate Belmont's and Butterfield's (1969) hypothesis and to devise procedures to eliminate STM deficits in retarded subjects. The authors have investigated acquisition and retrieval processes and their relationship to STM with non-retarded subjects, and applied studies to devise training procedures to eliminate the STM deficits of retarded subjects (Butterfield, Wambold and Belmont, 1972).

In all of the studies the authors employed a self-pacing, serial learning task which allowed independent observation of the effects of differential acquisition strategies and retrieval processes on STM. The apparatus automatically recorded the pause times (interitem interval) between letters which were plotted over serial positions to show the distribution of hesitations. Pause times plotted over serial position was used to provide graphic display of the S's acquisition strategy. For example the series A B C (pause for rehearsal) D E F was referred to as a 3 - 3, active - passive strategy. After the last letter in each list was presented, a test letter was exposed by the subjects. The S's task was to locate the position of the test letter in the list and indicate by pressing the appropriate response button. Retrieval strategy was operationally defined as correct response latency which was the time from the appearance of the test letter until the S responded correctly. Recall accuracy, the proportion of time that the S correctly responded, was the measure for STM. Both the correct latency and recall accuracy were also plotted over serial positions.

From the studies of non-retarded adults the authors concluded that interitem interval, the dependent measure for acquisition strategy, was a reliable measure of complicated acquisition strategies. Adults were found to employ two different kinds of acquisition strategies, active and passive, in learning the serial task. While actively rehearsing, the average interitem interval was longer at the position where rehearsal occurred. Passive acquisition resulted in accurate recall only over very short intervals of time, however active acquisition produced accurate recall over a much longer interval of time. In addition, adults change their acquisition and retrieval strategies to meet the response requirement of the task (Butterfield and Belmont, 1971).

According to Butterfield, Wambold and Belmont (1972) the secondary memory system consists of acquisition by actively rehearsing and the primary system consists of acquisition by passive non-rehearsal. They found that normal adults first search the primary memory and then the secondary system. For example, in the position A B C (pause for rehearsal) D E F, they would search the primary memory position D E and F and if the items were not located they would proceed to search the secondary memory system, positions A B and C.

The studies conducted to compare retarded and non-retarded subjects showed that the retarded generally did not use their secondary memory system. In other words, they did not actively rehearse on the serial learning task and consequently their interitem intervals plotted over serial positions were typically flat. They did however, use their primary memory system nearly as well as the non-retarded Ss (Belmont and Butterfield, 1969). For example, on the series

A B C (pause for rehearsal) D E F, the retarded Ss did not pause to rehearse but did perform as accurately and rapidly on the D E F positions as the non-retarded. In the A B C positions their recall accuracy was significantly less than the non-retarded group. In addition the retarded Ss did not modify their acquisition strategies or retrieval processes to meet the demands of the response requirements. Instead, they continued using the primary memory system despite the ineffectiveness of this system in many memory learning situations.

Butterfield, Wambold and Belmont (1972) trained mentally retarded Ss to use active rehearsal strategies in acquiring information. After training, Ss used their secondary memory system and performed as well on the rehearsed items as the non-retarded subjects. For example, they acquired information by A B C (pause for rehearsal) D E F rather than A B C D E F as was typical of their previous attempts. After training on appropriate acquisition strategies they performed as well as the non-retarded Ss at the A B C positions but for positions D E F they regressed to a level significantly lower than the non-retarded subjects. Therefore, after training, their secondary memory system was being used as well as non-retarded but their accuracy recall from their primary memory system was reduced from a level equal to the non-retarded to a level significantly lower. By training the retarded to retrieve from the passively acquired portions of the list (D E F) before searching the actively acquired list (A B C), the retarded group's recall was equal to the normal group's across all positions.

Short - Term Memory of the Reading Disabled

For organizational purposes, the studies which concluded that reading disabled Ss were deficient in STM skills are reviewed first (Rudisill, 1956; Rose, 1958; Alwitt, 1963; Birch and Belmont, 1964; Muehl and Kremenak, 1966; Beery, 1967).

Then, those studies which did not find the reading disabled deficient in STM skills are reviewed (Senf, 1969; Dornbush and Basow, 1970).

Rudisill (1956) tested span and accuracy of 43 advanced readers and 48 reading disabled third graders by presenting both digits and phrases tachistoscopically. The advanced readers consistently out-performed the reading disabled subjects. Consequently, the author concluded that there was a highly significant relationship between reading achievement and span and accuracy as measures of STM.

Rose (1958) administered the Stanford-Binet intelligence test to a group of 113 reading disabled youngsters. He found that they performed below the norm on the auditory memory span subtest. As a control against experimenter bias, he administered the same subtest to 80 normal youngsters and found that they performed average or above average on the test. He therefore concluded that the reading disabled were deficient in STM skills.

Alwitt (1963) compared STM performance of reading disabled and normal Ss in order to study the rate of memory trace decay. In the experimental task, serial stimulus cards with typewritten numbers randomly arranged in two rows of four digits, were presented to the subjects for one-tenth (.1) of a second.

Alwitt (1963) found that reading disabled Ss were inferior to normal subjects in performance of this task. However, he concluded that the differences in performance were not attributable to a decay of memory trace in the disabled subjects.

A series of studies (Birch and Belmont, 1964; Muehl and Kremenak, 1966; Beery, 1967) compared reading disabled and normal Ss' performances in matching auditory and visual stimuli. These studies were not specifically designed to study STM, but are mentioned in this review because they employ a task similar to those found in STM research. All these studies used stimuli similar to the Morse Code in which the "dots and dashes" were presented both auditorily and visually.

After the auditory or visual presentation the Ss were required to indicate if the two stimuli were alike or different. These studies found that good and poor readers differed in their abilities to immediately recall and match a series of auditory and visual stimuli.

The above cited studies tend to suggest that reading disabled Ss have STM deficiencies. The following studies, however, do not support this thesis.

Senf (1969) compared learning disability (LD) and normal boys on a variety of STM tasks to investigate Broadbent's (1958) hypothesis concerning the role of attention deficits in memory. In the experiments, an auditory and a different visual stimulus were presented simultaneously by a Bell and Howell Language Master.

The author concluded that learning disabled Ss were not characterized simply by a general deficit in STM and that their deficiencies could not be explained by an inability to shift attention from one modality to another. The learning disabled Ss did perform at a comparable level with the normal group in simple recall, when the order of recall was not included in the scoring criteria.

Dornbush and Basow (1970) used a total recall STM task to study the relationship between reading achievement and functioning in auditory and visual modalities. The study used a factoral design to study rate of presentation, modality order of report, and reading levels at each of four grade levels: first, third, fifth and ninth. A total of 72 reading disabled and normal Ss (18 at each grade level) were presented serial letters on 16mm film with a synchronous sound track.

The researchers found no significant differences in recall performance between the good and poor readers when any of the variables were manipulated. The authors suggested that the task, recalling numbers, may have been too simple and suggested that letters or other stimuli might yield different results.

The majority of the researchers who compared reading disabled and normal Ss concluded that STM deficits were present in the reading disabled (Rudisill, 1956; Rose, 1958; Alwitt, 1963; Birch and Belmont, 1964; Muehl and Kremenak, 1966; Beery, 1967). However, Senf (1969) and Dornbush and Basow (1970) found no differences between reading disabled and normal Ss on short - term memory.

Summary

Possible reasons for these opposite conclusions center on the variation in methods used by the researchers and problems they encountered while conducting their studies. For example, the conclusions by Rudisill (1956) and Alwitt (1963) may be questioned because the selection procedure identified two groups which were not only different in reading ability but were also significantly different in mental age. With such discrepancies in mental age, their conclusions must be viewed with skepticism. The study by Muehl and Kremenak (1966) did not provide adequate descriptions of the statistical treatment and results to allow an evaluation of this aspect of their studies. Furthermore, Muehl and Kremenak, along with Birch and Belmont (1964) and Beery (1967) were not studying STM per se. Their studies were included because their experimental tasks were similar to STM research. Rose's (1958) findings may also be questionable as the article did not describe selection procedures, explain how reading level was calculated or employ inferential statistics to assist in evaluating the STM performances of the 113 subjects.

Senf (1969) found that reading disabled subjects and normal readers did not have different STM attributes except when the scoring criteria for the tests did not specify that recall in a specific sequence was necessary. For organizational purposes Senf's study was included with Dornbush and Basow (1970), however his conclusions neither support nor reject the contention that STM is related to poor reading performance. Johnson's (1957) review was previously cited as supporting a STM - reading deficit relationship, however she does provide a description of the serious limitations of the studies included in her review.

With the limited number of STM studies of reading disabled subjects available and the variety of possible interpretations of the results, this writer concluded that the current status of STM as a critical subskill in reading is inconclusive. Face validity of STM concept alone would appear to be sufficient reason to continue research in this area. Most would agree that STM skills are necessary to read but does it follow that reading disabled students are deficient in this skill?

Previous researchers studying reading disabled Ss have used essentially one measure, recall accuracy, to study STM. Knowledge that poor readers are deficient on recall accuracy, however, is of little educational value unless this knowledge leads to remediation of the STM deficit and ultimately to improvement in reading. The STM model and experimental procedures employed by Butterfield, Wambold and Belmont (1972) to study STM processing of the retarded, provide a method of studying the separate contributions of acquisition and retrieval strategies and their relationship to recall accuracy. More important, they have altered recall accuracy by training the retardates to utilize effective acquisition and retrieval strategies.

The purpose of the present study is to clarify the relationship of STM to reading by studying accuracy of recall, acquisition strategies and retrieval processes. If it is found that reading disabled Ss utilize an ineffective acquisition and/or retrieval strategy, future studies may be designed to investigate various training approaches to improve STM by modifying acquisition and retrieval strategies of reading disabled children.

CHAPTER III

METHODS AND PROCEDURES

The present study was undertaken to determine if disabled readers are deficient in short - term memory (STM). The following research questions were examined:

1. Will reading disabled and normal Ss differ significantly on recall accuracy, acquisition strategies, and/or retrieval processes?
2. Will third, fifth and seventh grade Ss differ significantly on recall accuracy, acquisition strategies and/or retrieval processes?
3. Will there be significant differences on recall accuracy, acquisition strategies, and/or retrieval processes between: third grade reading disabled and normal Ss, fifth grade reading disabled and normal Ss and seventh grade reading disabled and normal subjects?

Two groups of 30 male Ss from the third, fifth and seventh grades were given a serial learning task which consisted of 32, eight-item lists of letters. The S's task was to recall the location of one of the letters following a brief presentation of each letter in the list. The Ss controlled the interitem interval but each of the letters had a fixed exposure duration of .05 seconds. The two groups were compared on recall accuracy (R+), interitem interval times (acquisition strategy) and latency of correct response (retrieval strategy).

Selection of the Subjects

Figure 1 provides a summary of the results and procedures used in selecting the Ss for this study. The samples used in this study were selected from the total population of 295 males enrolled in the third, fifth and seventh grades of Unified School District #450, Shawnee Heights, Kansas. From this group, a sample of 157 Ss were found who scored between 90 and 110 on the Otis - Lennon Mental Ability Test* (1967) administered by the school during the first semester of the 1971-72 school year. Of the 157 Ss who fell within the specified IQ score range of 90 to 110, 115 also met the achievement criteria for either the experimental or comparison group. The sample (N = 60) selected for this study was randomly drawn from the pool of 115 Ss with IQ scores between 90 and 110 who met the achievement criteria.

Achievement scores were obtained from the Stanford Achievement Test,* (1966) Form X, administered during the first semester of the 1971-72 school year. This test has three subtests for the third and fifth grades and only one subtest for the seventh grade. For the third and fifth grade reading disabled group a percentile rank of 30 or less on two of the three reading subtests (Word Meaning, Paragraph Meaning and Word Study Skills) was required. For the seventh grade reading disabled group a percentile rank of 25 or less on the Advanced Paragraph Reading was required. This percentile rank was selected to insure that all seventh grade Ss were at least one and a half grades below the national norm.

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*These test scores were used because they were available for all third, fifth and seventh grade students in the school districts.

FIGURE 1

SUMMARY OF SELECTION PROCEDURE

From the total group . . .

3rd Grade	N = 97	
5th Grade	N = 94	= 298
7th Grade	N = 107	

. . . with IQ scores between 90 and 110 . . .

3rd Grade	N = 63	
5th Grade	N = 48	= 157
7th Grade	N = 46	

. . . who met criteria on achievement test for the experimental and comparison group . . . .

	Group 1*	Group 2**	
3rd Grade	N = 29	N = 25	
5th Grade	N = 16	N = 17	= 115
7th Grade	N = 14	N = 14	

. . . a random sample was selected . . .

3rd Grade	N = 10	N = 10	
5th Grade	N = 10	N = 10	= 60
7th Grade	N = 10	N = 10	

*Group 1 represented the reading disabled Ss.

**Group 2 represented the normal Ss.

Achievement criteria for the normal comparison group from the third and fifth grades was a percentile rank of 50 or more on two of the three reading subtests; for the seventh grade normal group, achievement criteria was a score on or above the 50th percentile on the Advanced Paragraph Reading subtest.

Apparatus and Materials

The S faced a 20 X 20 inch sloped, black, plexiglass panel. A row of nine transparent plexiglass windows was centered 10 inches from the top of the panel, through which the S viewed a list of eight letters and one test letter. Each window measured 3/8 inch high and 7/8 inch wide and was separated from the next window by 1/8 inch. The windows also functioned as response buttons and by applying light pressure to any of the windows, the student could indicate the location of the test item in the serial list.

A letter - exposure switch located on the table in front of the panel permitted the students to expose and view the letters at any rate. Each list consisted of eight letters on an 8 X 10 inch white card. (See Appendix B for a sample.) To present the letters of each list, the card was placed in a plexiglass card - carrier. This carrier was held in place behind the panel by pins of two solenoids which fit into notches cut into the back of the card - carrier. Each time the student pushed the letter - exposure switch the circuit was closed and the two solenoids were activated sequentially, causing the card - carrier to drop 1/4 inch.

The lists were constructed so that with each push - to - see response, the operation of the first solenoid dropped the card - carrier exposing a stimulus letter and was followed by the activation of the second solenoid which lowered the carrier again and resulted in the removal of the letter from view. There was a 0.50 second delay between the activation of the two solenoids, producing a stimulus duration of 0.50 seconds. The time from the offset of each stimulus to the moment S made his next push - to - see response (including the test item) was measured by a Sodeco printout counter to 0.50 second accuracy. For each trial the apparatus automatically recorded a student's complete pattern of hesitations (interitem interval) as he proceeded through the list, and the time between the onset of the probe letter and the S's recall response.

In discussing a similar apparatus, Ellis (1970) noted the following practical and conceptual advantages:

> (a) Many aspects of the task may be varied, including item exposure duration, interitem interval, interval between last item and probe, and stimulus materials (numbers, letters, pictures, etc.). (b) Time relations are precisely controlled. (c) The partial report or probe technique provides an evaluation of short - term retention with the interfering effects of the recall process minimized. (d) The recall is a "key press" which seems less complex than an oral or written response. (e) The scale of measurement permits the assessment of the behavior of Ss differing widely in ability level. (f) Conceptually, the model has high face validity as a measure of STM, yielding a serial position effect similar to that found in immediate free recall and other STM tasks [p. 2].

Procedures

The learning task was administered in a classroom essentially free of extraneous stimuli. Only the subject and the experimenter were present. Each session was conducted individually with reading disabled and normal Ss alternately participating in the approximately 45 minute sessions. During the session Ss completed one demonstration and two practice lists prior to beginning. (See Appendix C for specific instructions.) To insure that all Ss could read the letters, they were asked to name the twelve letters used in this study. (See Appendix D for list of letters.) Each list was a unique order of randomly generated letters from a 12 - letter pool: H, J, K, L, N, P, R, Q, V, W, Z, X.

Following the last letter in the list, Ss pressed the exposure button to present the test letter. The Ss then attempted to recall the letter and indicate by pressing one of the window - response buttons. If the correct response button was pressed, the letter would disappear immediately. If an incorrect response were made, the letter would remain in view until the examiner removed the list.

Dependent Measures

Three dependent measures were used to determine recall accuracy, acquisition strategies and retrieval processes in reading disabled and normal subjects.

The first measure, recall accuracy (R+) was the number of probe items correctly located. According to Ellis (1970) this measure has a high face validity as a measure of STM.

The second measure, interitem interval, was the amount of time from the presentation of the stimulus until the subject pushed the button to expose the next letter. Because Ss were free to pause between letters for as long as they wanted, this interitem time was taken to represent the amount and distribution of rehearsal, which in turn represents S's acquisition strategy. For example, if the series presented were A B C D E F, and the student paused significantly longer between C and D than he did between any of the other letters, it would suggest that he was rehearsing the first three letters of the sequence before going on to learn the next three letters. Previous research (Butterfield and Belmont, 1971) has indicated that such pause times do in fact provide a reliable measure of rehearsal.

The third dependent measure, correct recall latency, was used to measure the retrieval process. Measuring this time span for each of the eight positions represented the pattern of recall or retrieval strategy of the subjects. Correct recall latency time was the time between the presentation of the test item and the instant the subject depressed the correct response window. For example, suppose the series A B C D E F were presented to the subject. The research (Belmont and Butterfield, 1969) with normal adults shows that if the letter F were the test item, correct recall latency would be lower than if the test item had been A. In other words, the subject would remember the position of "F" more quickly than the position of "A"; that is, the more quickly the subject remembers the position the lower the recall latency. Measuring this time span then gives an indication whether or not normal readers and reading disabled Ss recalled in the same pattern.

Data Analysis Procedures

One score was used to represent each S's pattern of rehearsal at each position from the 32, eight item lists. By dividing the 32 lists into four blocks and using a mean of the median of each block, a mean interitem interval time was obtained. The first and third blocks had nine lists and the second and fourth had seven. (See Appendix E for blocks 1 through 4.) Since each block was an odd number of lists (7 or 9), the median was obtained by locating the middle score. The mean of these medians, plotted over serial positions provided a graphic display of Ss' acquisition strategies.

The Ss' mean scores of the block medians were analyzed using Dixson's (1968) computer program for a 2 X 3 X 8 mixed analysis of variance (reading disabled and normal X third, fifth and seventh X eight serial positions). The same design was used to analyze the correct recall data (R+), except the total number of letters correctly recalled at each position was used to represent each S's R+ score.

Insufficient data were obtained on the correct recall latency measure to allow a comparison at each serial position. Therefore, the data from the first six positions were combined and compared to positions seven and eight with a 2 X 3 X 3 mixed analysis of variance. This analysis allowed a comparison between the two conditions (reading disabled and normal) from three grade levels (grades 3, 5, and 7) at three positions (positions 1 through 6, 7, and 8). For this analysis, the means of the medians of positions one through six, at each grade level, were compared to the means of the medians of positions seven and eight.

For those subjects who did not recall any of the letters from positions seven or eight, the median of the other nine Ss in their grade were used. For the analysis of the R+, interitem interval, and correct recall latency data, the level of significance was set at .05. Chapter IV provides a summary and discussion of the comparison of the reading disabled Ss to the normal Ss on recall accuracy, acquisition strategies, and retrieval processes.

CHAPTER IV

RESULTS AND DISCUSSION

This study was designed to compare the short - term memory (STM) processes of normal and reading disabled subjects and thereby discern what role STM plays in a child's ability to read. In addition, this study was conducted to explore the feasibility of manipulating acquisition and retrieval strategies in future attempts to improve STM performance of reading disabled students. Ten reading disabled males, randomly selected from the poorest readers in the third, fifth and seventh grades were compared with a randomly selected normal group from the same grade levels.

The recall accuracy, acquisition strategies and retrieval processes of these 60 Ss were compared by analyzing their responses on a serial learning task. This test was presented to each subject so that each of the eight serial positions could be probed four times. Number of items correctly recalled (R+), was the dependent variable for recall accuracy. The amount of rehearsal was measured by the interitem interval time and represented the S's acquisition strategy for remembering the serial task. Response latency (R+ Latency), time from the onset of the test or probe item until the S responded correctly, was used as a measure of retrieval. This chapter presents a description of the samples, results and discussion of the comparison between reading disabled and normal Ss' R+ performances, acquisition strategies and retrieval processes.

Description of Subjects

As described in Chapter III, 60 male Ss were selected from the third, fifth and seventh grades from Shawnee Heights, Kansas. The means, ranges and standard deviations for IQ scores, chronological age in years and reading levels are shown in Table 1. The IQs were assessed with the Otis Lennon Mental Ability Test, administered during the 1971-72 school year. Reading levels were the mean of the reading subtests from the Stanford Achievement Test, Form X, except for the seventh grade level for which this test provides only one subtest. Individual data on IQ, age and reading grade level is shown in Appendix A. These data were analyzed with a Fisher's t statistic and the two groups were found to be non-significantly different on CA and IQ, and significantly different on reading level at the .05 level of significance.

Results of R+ Comparison

Table 2 shows the mean number of letters correctly recalled by the reading disabled and normal groups at each grade level and serial position. (Raw data are shown in Appendix A.)

A visual examination of these data show more letters were correctly recalled from positions seven and eight than from positions one through six. The range for R+ varied from approximately 15% correct at position 2 for third grade Ss, to over 85% recall at position eight for the seventh grade subjects. The mean R+ for the normal Ss was slightly higher than for the reading disabled group except for positions three and five.

TABLE 1

MEANS, RANGES, AND STANDARD DEVIATION
OF IQ, AGE, AND READING LEVEL FOR THE TWO GROUPS

		IQ			Age			X̄ Reading Level		
	N	Mean	Range	S.D.	Mean	Range	S.D.	Mean	Range	S.D.
Reading Disabled										
Third Grade	10	99.5	94-109	4.76	9.10	8.17-10.17	1.20	2.13	1.93- 2.37	.20
Fifth Grade	10	97.8	91-105	5.07	10.39	10.17-10.69	.30	3.82	2.87- 3.90	1.12
Seventh Grade	10	98.2	91-105	4.31	12.60	11.75-13.42	.60	4.55	2.50- 5.60	1.06
Total Group	30	98.5	91-109	4.71	10.70	8.70-13.42	.70	3.50	1.93- 5.60	.79
Normal										
Third Grade	10	100.1	93-110	6.65	8.68	7.92- 9.58	.50	4.70	2.87- 5.33	1.19
Fifth Grade	10	105.9	101-109	3.03	10.50	10.30-11.40	.37	6.02	4.73- 6.50	.72
Seventh Grade	10	104.9	102-109	2.51	12.55	11.83-13.47	.56	8.04	7.00-10.00	1.08
Total Group	30	103.6	91-110	4.06	10.78	7.92-13.42	.48	6.25	2.87-10.00	1.00

TABLE 2

MEAN NUMBER AND STANDARD DEVIATIONS (S.D.)*
OF LETTERS CORRECTLY RECALLED PER SERIAL POSITION

	POSITIONS 1	2	3	4	5	6	7	8	$\overline{X}$
Reading Disabled									
Third Grade	1.0 (1.00)	.6 (.66)	.9 (1.04)	1.2 (1.08)	1.2 (1.08)	1.5 (.81)	1.8 (1.33)	2.3 (1.19)	1.31 (1.02)
Fifth Grade	1.2 (1.25)	1.2 (.87)	1.0 (.89)	.9 (.70)	.7 (.46)	.8 (.98)	2.0 (.89)	3.1 (1.30)	1.36 (.92)
Seventh Grade	.7 (.78)	.6 (.49)	.9 (.94)	.7 (.78)	.9 (.83)	.6 (.91)	1.9 (1.22)	3.1 (1.14)	1.18 (.89)
Group $\overline{X}$	.96 (1.01)	.80 (.67)	.93 (.97)	.93 (.85)	.93 (.79)	.97 (.90)	1.90 (1.14)	2.83 (1.21)	1.28 (.94)
Normal									
Third Grade	1.0 (.89)	.6 (.66)	.3 (.64)	1.3 (.90)	.8 (.87)	1.3 (1.01)	1.9 (.83)	3.0 (1.18)	1.28 (.87)
Fifth Grade	1.0 (1.34)	1.5 (1.36)	1.2 (.87)	1.2 (.87)	.6 (.92)	.9 (.70)	2.3 (1.27)	3.0 (1.10)	1.46 (1.05)
Seventh Grade	1.0 (1.38)	1.5 (1.29)	.9 (.94)	.9 (.94)	.5 (.81)	1.1 (.54)	2.6 (.92)	3.5 (.67)	1.51 (.94)
Group $\overline{X}$	1.03 (1.20)	1.20 (1.10)	.80 (.82)	1.13 (.90)	.63 (.87)	1.10 (.75)	2.27 (1.01)	3.17 (.98)	1.42 (.95)

*Standard deviations are indicated by parentheses.

The three graphs found in Figure 2 present the same data expressed in mean percent correct for the reading disabled and normal Ss at each grade level. A visual examination of these graphs shows that the fifth and seventh grade subjects performed slightly higher at most all positions, however the third grade reading disabled Ss were slightly higher at three positions. Both the reading disabled and normal groups had better recall in the last two positions than at any of the other six positions.

The statistic selected to analyze the R+ data was a 2 X 3 X 8 mixed analysis of variance. This analysis provided a comparison between the two conditions (reading disabled and normal) from three grade levels (third, fifth and seventh) at each serial position (1 - 8). A summary of analysis is shown in Table 3. None of the F values on the between variables approached significance. There were no significant R+ main effects between the two conditions or between the three grade levels.

The significant F value for within positions ($F = 35.35$; $df = 7,378$; $p < .05$) indicated that some positions were correctly recalled more often than others. However, the non-significant F score for the interactions between conditions and between grade levels indicated that the positions that were more often correctly recalled were the same for Ss from all conditions and grade levels. Conversely, those positions that were missed more frequently were the same for subjects from all grade levels and all serial positions.

FIGURE 2

A COMPARISON OF READING DISABLED AND NORMAL SUBJECTS' RECALL ACCURACY

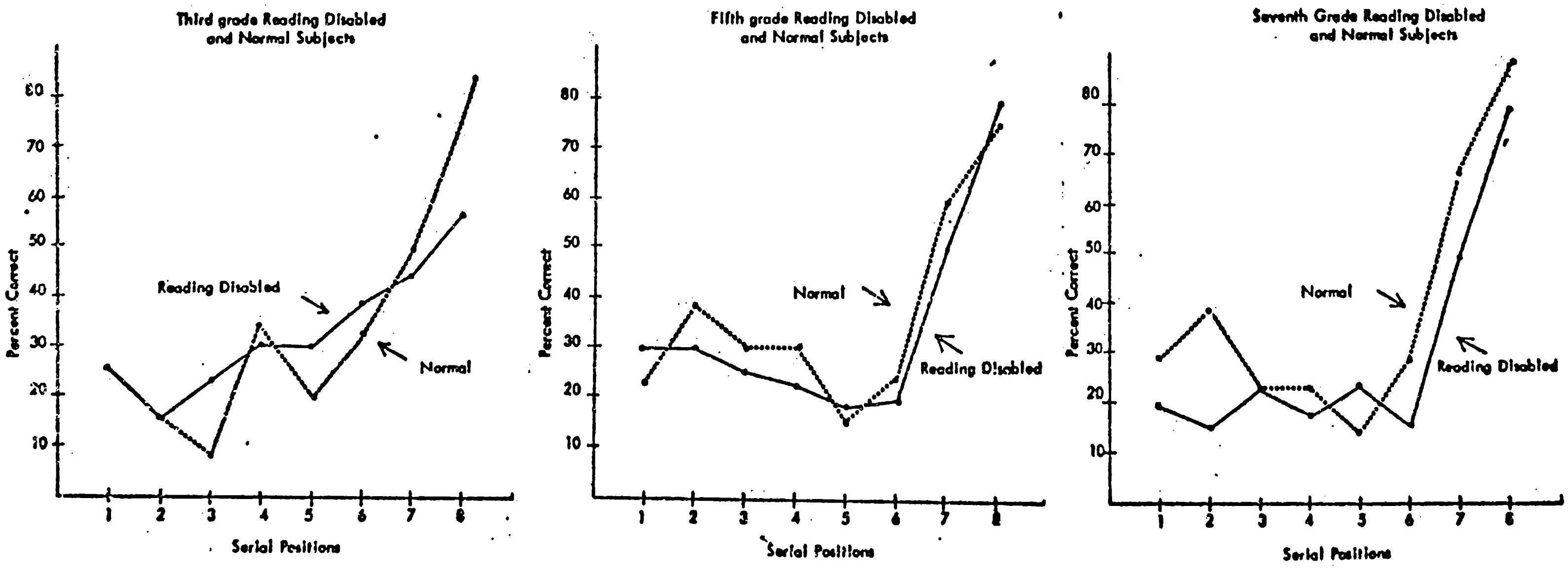


TABLE 3

MIXED ANALYSIS OF VARIANCE OF RECALL ACCURACY (R+) OF READING DISABLED AND NORMAL SUBJECTS

SOURCE	SS	DF	MS	F
Between		59		
Conditions	2.13	1	2.13	1.88
Grades	1.14	2	.57	.50
C X G	2.88	2	1.44	1.27
Error b	61.30	54	1.14	----
Within		420		
Positions	255.63	7	36.52	35.35*
P X C	6.50	7	.93	.90
P X G	21.03	14	1.50	1.45
P X C X G	6.09	14	.43	.42
Error w	390.50	378	1.03	----

*significant beyond the .05 level

From this analysis the following comments concerning the original research questions can be stated:

1. There was no significant difference in recall accuracy (R+) between the reading disabled and normal groups.

2. There was no significant difference in recall accuracy between the third, fifth and seventh grade subjects.

3. There was no significant difference in recall accuracy between:
   (a) third grade reading disabled and normal subjects;
   (b) fifth grade reading disabled and normal subjects; and
   (c) seventh grade reading disabled and normal subjects.

<u>Results of Comparison on Acquisition Strategy</u>

Table 4 shows the mean interitem interval times (expressed in .05 sec.) of the reading disabled and normal groups at each grade level and serial position. For example a score of 20.00 would be equal to one second (.05 X 20.00 = 1 sec.) Appendix B provides raw data on this variable.

A visual examination of this table shows that reading disabled and normal <u>S</u>s from all grade levels appear to be relatively consistent in the amount of time spent between letters. The normal group's mean hesitation time per serial position was slightly slower than the reading disabled group's in the last four positions. The greatest difference was at position one with the reading disabled group responding only slightly slower than the normal group.

TABLE 4

MEAN INTERITEM INTERVAL TIME IN .05 OF A SECOND AND STANDARD DEVIATIONS* BETWEEN LETTERS BY SERIAL POSITION

	POSITIONS																	
	1		2		3		4		5		6		7		8		$\overline{X}$	
Reading Disabled																		
Third Grade	19.60	(3.98)	19.73	(3.82)	20.28	(4.43)	19.85	(3.93)	19.28	(4.17)	19.78	(4.16)	19.65	(3.98)	17.73	(3.88)	19.48	(4.04)
Fifth Grade	19.58	(4.38)	20.60	(6.84)	20.85	(7.79)	20.15	(6.60)	21.05	(8.37)	20.75	(8.12)	19.84	(7.10)	17.70	(7.08)	20.06	(7.04)
Seventh Grade	16.85	(3.71)	16.98	(3.99)	17.25	(4.34)	16.75	(4.45)	17.08	(4.20)	17.00	(4.29)	16.68	(4.27)	15.25	(3.74)	16.73	(4.12)
Group $\overline{X}$	18.68	(4.02)	19.10	(4.88)	19.46	(5.52)	18.92	(4.99)	19.13	(5.58)	19.18	(5.52)	18.72	(5.12)	16.89	(4.90)	18.76	(5.07)
Normal																		
Third Grade	17.75	(5.61)	18.20	(6.05)	16.53	(6.02)	18.50	(5.95)	18.35	(6.08)	18.55	(6.27)	18.23	(6.19)	16.30	(6.14)	18.05	(6.04)
Fifth Grade	21.05	(3.78)	22.43	(4.13)	23.10	(4.22)	23.60	(4.62)	24.20	(6.39)	24.80	(8.83)	24.63	(8.65)	21.58	(7.26)	23.17	(5.99)
Seventh Grade	14.40	(4.99)	14.55	(4.85)	14.80	(4.95)	14.85	(4.72)	14.65	(4.56)	14.40	(4.48)	14.40	(4.75)	12.93	(3.69)	14.37	(4.62)
Group $\overline{X}$	17.73	(4.79)	18.39	(5.01)	18.81	(5.06)	18.98	(5.10)	19.07	(5.68)	19.25	(6.53)	19.08	(6.53)	16.93	(5.70)	18.53	(5.55)

*Standard deviations are indicated by parentheses.

Figure 3 presents the same data expressed in seconds per interitem interval for the three grade levels at each serial position. A visual examination of this graph shows that neither group rehearsed noticeably at any serial position. The third and seventh grade reading disabled Ss were slightly slower at all serial positions. In the fifth grade group, reading disabled Ss responded faster than the normal subjects at all serial positions.

The statistic selected to measure the interitem interval times was a 2 X 3 X 8 mixed analysis of variance. This analysis provided a comparison between the two conditions (reading disabled and normal) from three grade levels (third, fifth and seventh) at the eight serial positions.

As shown in Table 5 significant differences were found between the grade levels ($F = 6.56$; $df = 2,54$; $p < .05$) and within serial positions ($F = 13.18$; $df = 7,378$; $p < .05$). Non-significant interactions were found within the serial positions X conditions, serial positions X grade level, and the positions X conditions X grades.

This analysis shows that there were no significant differences between reading disabled and normal subjects on acquisition strategy. Despite the significant difference between grades shown by the interitem interval analysis, the grades did not employ a different rehearsal strategy as was shown by the non-significant position X grade interaction. Nor did the reading disabled and normal subjects at each of the grade levels employ different acquisition strategies as was shown by the non-significant positions X conditions X grades interaction.

FIGURE 3

A COMPARISON OF INTERITEM INTERVAL TIMES FOR READING DISABLED AND NORMAL SUBJECTS

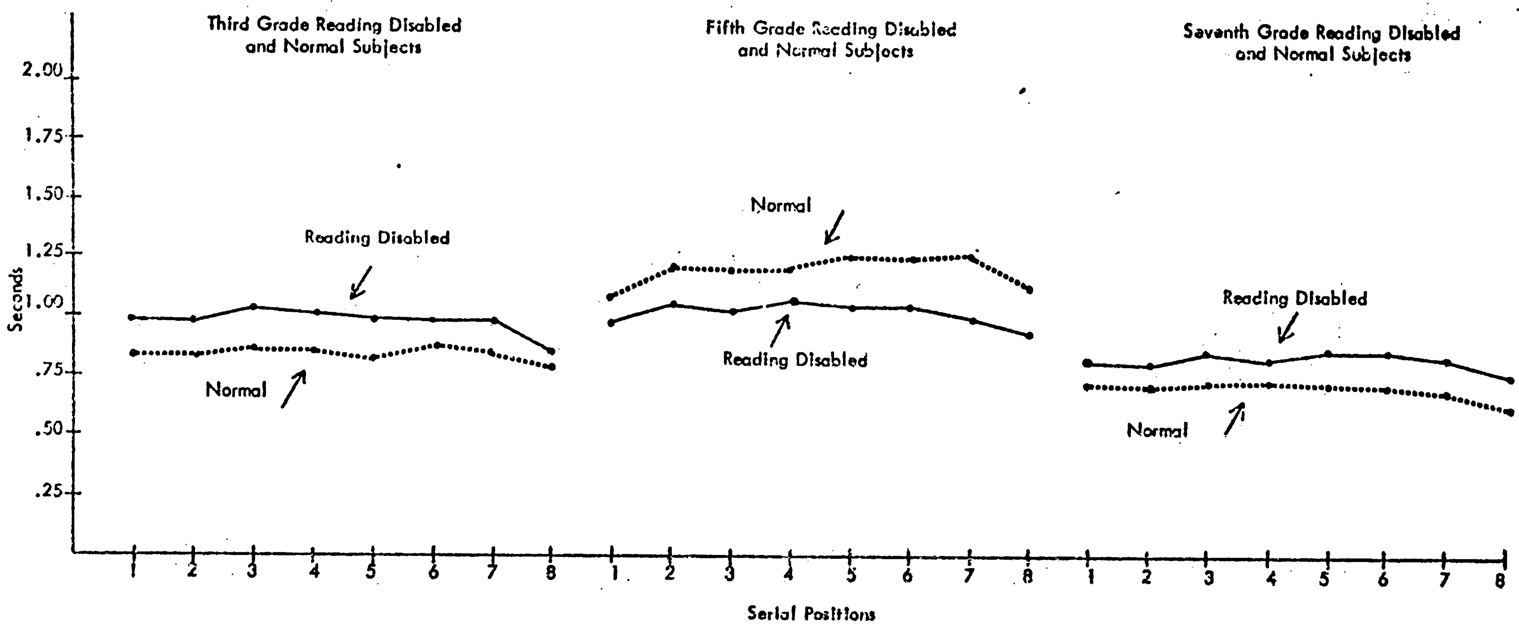


TABLE 5

MIXED ANALYSIS OF VARIANCE OF INTERITEM INTERVAL OF READING DISABLED AND NORMAL SUBJECTS

SOURCE	SS	DF	MS	F
Between		59		
Conditions	6.22	1	6.22	.03
Grades	2,949.35	2	1,474.67	6.56*
C X G	684.41	2	342.21	1.52
Error b	12,135.62	54	224.73	----
Within		420		
Positions	247.98	7	35.43	13.18*
P X C	23.15	7	3.31	1.23
P X G	52.81	14	3.77	1.40
P X C X G	28.60	14	2.04	.76
Error w	1,015.97	378	2.69	----

*significant beyond the .05 level

From this analysis the following comments concerning the original research questions can be stated:

1. There were no significant differences between the reading disabled and normal groups' acquisition strategies employed in this study.
2. There were no significant differences between the acquisition strategies of the third, fifth and seventh grade subjects.

3. The acquisition strategy was not significantly different between:

   (a) third grade reading disabled and normal subjects;

   (b) fifth grade reading disabled and normal subjects; and

   (c) seventh grade reading disabled and normal subjects.

<u>Results of Comparison of R+ Latency</u>

Table 6 shows the number of <u>S</u>s from each grade level who failed to recall any of the four test letters at each serial position. Nearly one-half of the <u>S</u>s failed to recall test letters from positions one through six. For positions seven and eight, only three reading disabled and two normal <u>S</u>s failed to recall any of the four test letters.

The data from the first six positions were collapsed and compared to positions seven and eight. Table 7 provides a summary of the means of the medians of the first six positions and for serial positions seven and eight.

A visual examination of this data shows that the reading disabled group's mean R+ latency time was more than the normal comparison group. For both groups, the mean R+ latency time decreases as the grade level increases. Table 8 summarizes the results of a 2 X 3 X 3 mixed analysis of variance which compared the two conditions (reading disabled and normal) from three grade levels (grades 3, 5 and 7) at three serial positions (1 - 6, 7 and 8). There were no significant differences at the .05 level between the two conditions. There was a significant grades main effect ($F = 5.05$; $df = 2,54$; $p < .05$) and, a significant main effect within positions ($F = 28.52$; $df = 2,108$; $< p$ .05).

TABLE 6

SUMMARY OF THE NUMBER OF SUBJECTS WHO FAILED TO CORRECTLY RECALL THE FOUR LETTERS AT EACH SERIAL POSITION

	POSITIONS								
	1	2	3	4	5	6	7	8	Total
Reading Disabled									
Third Grade	5	5	5	4	4	1	1	1	26
Fifth Grade	3	3	3	4	3	5	0	0	21
Seventh Grade	5	4	4	5	4	6	1	0	29
Group $\overline{X}$	4.3	4.0	4.0	4.3	3.7	4.0	.7	.3	2.5
Normal									
Third Grade	4	5	8	2	4	3	0	1	27
Fifth Grade	6	3	2	3	6	3	1	0	24
Seventh Grade	5	3	5	5	7	1	0	0	26
Group $\overline{X}$	5.0	3.7	5.0	3.3	5.7	2.3	.3	.3	2.6

TABLE 7

MEAN R+ LATENCY AND STANDARD DEVIATIONS*
FOR POSITIONS ONE THROUGH SIX AND POSITIONS SEVEN AND EIGHT

	POSITIONS 1-6		7		8		Mean	
Reading Disabled								
Third Grade	3.81	(2.02)	2.11	(0.38)	1.70	(0.38)	2.54	(0.93)
Fifth Grade	2.50	(1.14)	2.13	(1.32)	1.54	(0.55)	2.05	(1.00)
Seventh Grade	2.17	(0.60)	1.40	(0.45)	1.32	(0.26)	1.63	(0.44)
Group $\overline{X}$	2.83	(1.25)	1.88	(0.72)	1.52	(0.40)	2.07	(0.79)
Normal								
Third Grade	2.62	(0.84)	2.04	(1.44)	1.57	(0.46)	2.08	(0.91)
Fifth Grade	2.18	(0.80)	1.83	(1.43)	1.55	(0.33)	1.85	(0.85)
Seventh Grade	2.21	(0.72)	1.55	(0.38)	1.34	(0.31)	1.70	(0.47)
Group $\overline{X}$	2.34	(0.79)	1.81	(1.08)	1.49	(0.37)	1.88	(0.74)

*Standard deviations are indicated by parentheses.

TABLE 8

SUMMARY OF 2 X 3 X 3 MIXED ANALYSIS OF VARIANCE OF RESPONSE LATENCY OF READING DISABLED AND NORMAL SUBJECTS

SOURCE	SS	DF	MS	F
Between				
Conditions	1.76	1	1.76	1.42
Grades	12.53	2	6.26	5.05*
C X G	2.17	2	1.06	.85
Error b	66.97	54	1.24	----
Within				
Positions	36.51	2	18.25	28.52*
P X C	1.92	2	.96	1.60
P X G	4.92	4	1.23	1.92
P X C X G	2.40	4	.60	.94
Error w	68.92	108	.64	----

*significant beyond the .05 level

This analysis showed that there were no significant differences between the reading disabled and normal subjects retrieval process. There was a significant correct recall latency difference between grades. However, the non-significant positions X grades interaction showed that this difference was not due to different retrieval processes. Instead, the difference was caused by differences in speed of response rather than patterns of response.

The non-significant position X condition and non-significant position X condition X grades interactions showed that there were no significant differences in retrieval processes between the conditions, between grades or within the grades.

From this analysis the following comments concerning the original research questions can be stated:

1. There were no significant differences between the reading disabled and normal groups' retrieval processes.
2. There were no significant differences between the third, fifth and seventh grades' retrieving processes.
3. There were no significant differences in retrieval processes between:
   (a) third grade reading disabled and normal subjects;
   (b) fifth grade reading disabled and normal subjects; and
   (c) seventh grade reading disabled and normal subjects.

Discussion

The results of this study indicate that: (1) reading disabled and normal Ss do not differ significantly on recall accuracy, acquisition strategies or retrieval processes; (2) third, fifth and seventh grade Ss do not differ significantly on recall accuracy, acquisition strategies, or retrieval processes; and (3) recall accuracy, acquisition strategies and retrieval processes do not differ between third grade reading disabled and normal subjects, fifth grade reading disabled and normal subjects, or between seventh grade reading disabled and normal subjects.

The findings concerning R+ of reading disabled subjects conflict with a majority of the studies (Rudisill, 1956; Rose, 1958; Alwitt, 1963; Muehl and Kremenak, 1966; Beery, 1967; Birch and Belmont, 1968) and with the conclusions drawn by most writers (Betts, 1950; Johnson, 1957; Neville, 1966; Johnson and Myklebust, 1967; Harris, 1970). The findings do support the position of Senf (1969) and Dornbush and Basow (1970) regarding the inability of R+ to discriminate between good and poor readers. The non-developmental differences of R+ found in the present study are not consistent with Dornbush's and Basow's findings (1970). The following speculations concerning these discrepancies must be viewed as conjecture since data is not available to provide insight into these comments.

One possible explanation for the finding that R+ did not discriminate between good and poor readers and that it was not showing a developmental trend is that the task was too difficult. If the eight item probe task was too difficult a "floor effect" would occur and eliminate the possibility of obtaining differences. This might also explain why the two groups did not utilize rehearsal as a mnemonic device. If the task was too difficult, Ss may not have taken time to rehearse and instead proceed immediately to the terminal items in the list which could be recalled from primary memory. There was evidence that the latter items, e.g., positions seven and eight, were correctly recalled more frequently by all grade levels. Reducing the length of the serial task list with a similar sample would be possibly a method of investigating this hypothesis. It is interesting to note that Dornbush and Basow (1970) suggested that their results may have been a function of a task that was too easy.

Another possibility is that the procedures and measures used to select the sample did not sufficiently differentiate the groups. This, however, would not explain the lack of rehearsal strategies, especially by seventh grade subjects; not only did this study find no differences between the two groups, there was no evidence of rehearsal by any of the grade levels from either group.

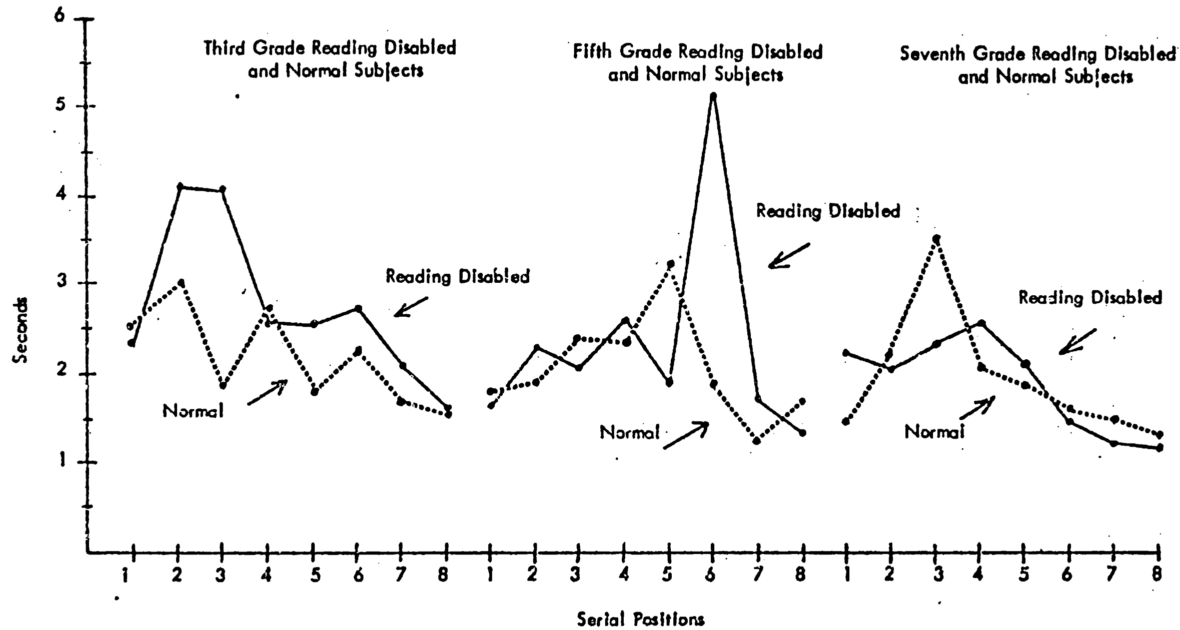
Since the IQ scores used in this study were obtained from a group intelligence test which required reading, it is possible that the reading disabled Ss may actually have had higher IQ scores than the normal subjects. If this were true, STM deficit differences may have been eliminated due to a depressed IQ score. If this did occur, the higher "actual" IQ may raise the STM ability to a level greater than one would expect based upon the Ss' reading levels. Using an individual IQ test to identify future groups would provide an alternative approach to this possible problem.

Although the analysis of R+ performances clearly showed no significant differences in method of retrieval between the two groups, Figure 4 does show some trend data. By dropping those Ss who did not recall any of the four letters from a given serial position, and plotting the median score of each position, noticeable differences between method of retrieving information can be found. The general slope of the line for the third grade subjects is from left to right, suggesting that they retrieved in a backward order, searching from position eight. The fifth and seventh grade Ss, however, appear to have a different pattern of retrieving information on this STM task. Instead of a downward slope from left to right, they have a general upward slope through the first portion of the list and a downward slope in the latter portions. This pattern suggests that they first search the last portions, beginning with eight and then search the first portions beginning with the first part of the list.

These findings, however, must be viewed as "trends" in the data, since insufficient data were available to adequately describe the retrieval strategies employed by the reading disabled and normal groups. Position six for fifth grade reading disabled Ss, for example, appears to reflect differences between the two groups' method of retrieval, however, as is shown in Table 6, this was also the position which had the most number of Ss who failed to recall any of the letters. These results therefore, may be "chance" differences rather than significant R+ latency differences. The same situation occurs in positions two and three for third grade Ss, therefore these "peaks" in the graph may not reflect the actual trend for these grade levels. Generally, however, this trend does not appear to

FIGURE 4

A COMPARISON OF READING DISABLED AND NORMAL SUBJECTS' CORRECT RECALL LATENCY



be different between reading disabled and normal Ss from any of the three grade levels, therefore supporting the previous results.

Poor selection procedures, experimental bias, a variety of environmental conditions, chance performance and a sundry of "unknown" variables plague experimental research and could have influenced the results of this study. But the fact remains that no differences were found between the two groups on any of the three dimensions and that STM deficiency may not be a contributing factor to poor reading. Chapter V provides a summary of the results, conclusions and a brief description of future research possibilities which were generated through this study.

CHAPTER V

SUMMARY

The purpose of this study was to investigate the short - term memory (STM) process of reading disabled children.

Thirty reading disabled and thirty normal male Ss were randomly selected from the third, fifth and seventh grades for the study. They were given a serial learning task which consisted of 32, eight - item lists of letters. The Ss' tasks were to recall the location of one of the letters following a brief presentation of each letter in the list. The S controlled interitem interval, but each of the letters had a fixed exposure duration of .05 seconds.

The two groups were compared on recall accuracy, interitem interval (acquisition strategy) and correct recall latency (retrieval strategy).

Recall accuracy was the number of items correctly located. Interitem interval time was the amount of time from the presentation of stimulus until the S pushed the button to expose the next letter. The Ss were free to pause between letters for as long as they wanted. This interitem time was taken to represent the amount and distribution of rehearsal, which in turn represents S's acquisition strategy.

Correct recall latency was the time between the presentation of the probe item and the instant the S depressed the correct response window. Measuring this time span indicated S's retrieval strategy.

The data necessary to determine recall accuracy, acquisition strategy and retrieval strategy was automatically recorded by the apparatus. This apparatus consisted of a panel with nine windows through which the S viewed a serial list of eight letters and one test letter. The windows also functioned as response buttons. The S controlled the interitem interval by using a letter exposure switch in front of the panel.

The statistical procedures used to analyze the recall accuracy and interitem interval data was a 2 X 3 X 8 mixed analysis of variance. This analysis provided a comparison between the two conditions (reading disabled and normal) from three grade levels (third, fifth and seventh) at the eight serial positions.

There were no significant recall accuracy (R+) differences between the two conditions, among the three grades, or on the condition X grades interaction. There was a significant difference within positions. However, there were no significant interactions on the positions X conditions, positions X grades, or positions X conditions X grades analysis.

The significant F value between positions indicated that some positions were correctly recalled more often than others. However, the non-significant F value for the interactions between conditions and between grade levels indicates that the positions that were more often correctly recalled were the same for Ss from all conditions and grade levels. Conversely, those positions that were missed more frequently were the same for Ss from all grade levels and all positions.

The results of the interitem interval analysis showed that there were no significant differences between reading disabled and normal Ss on acquisition strategy. There was a significant difference between grades on the interitem interval analysis, however, the grades did not employ a different rehearsal strategy as was shown by the non-significant position X grade interaction. The reading disabled and normal Ss at each of the three grade levels also did not employ different acquisition strategies as was shown by the non-significant positions X conditions X grades interactions.

Insufficient data were available to compare the two groups on correct recall latency at each position. The data from the first six positions was therefore collapsed and compared to positions seven and eight. A 2 X 3 X 3 mixed analysis of variance was used to compare the two conditions from three grade levels at three positions (1 - 6, 7, and 8).

This analysis showed that there were no significant differences between the reading disabled and normal Ss' retrieval processes. There was a significant correct recall latency difference between grades. However, the non-significant positions X grades interaction showed that this difference was not due to different retrieval processes. Instead, the difference was caused by differences in speed of response rather than patterns of response. This analysis also showed a significant position main effect. However the non-significant position X condition and non-significant position X condition X grade interaction showed that there were no significant differences in retrieval processes between the conditions, between grades or within the grades.

The results of these analyses warrant the following conclusions:

1. Reading disabled and normal subjects do not differ significantly on recall accuracy, acquisition strategies, and/or retrieval processes.
2. Third, fifth and seventh grade subjects do not differ significantly on recall accuracy, acquisition strategies, and/or retrieval processes.
3. There are no significant differences on recall accuracy, acquisition strategies, and/or retrieval processes between:
   (a) third grade reading disabled and normal subjects;
   (b) fifth grade reading disabled and normal subjects; and
   (c) seventh grade reading disabled and normal subjects.

Limitations

The conclusions drawn from this study are subject to the following possible limitations:

1. Only one achievement test was used to measure reading performance. A battery of informal and standardized reading tests might not have identified the same reading disabled and normal subjects.
2. The use of a group intelligence test which requires reading may not provide the same results as would an individually administered intelligence test which stresses verbal rather than reading skills.
3. The use of one person who was fully acquainted with the experimental conditions to provide instructions to a majority of Ss may have influenced the results. A double blind design would have reduced the probability of this limitation occurring.

4. The subjects were selected from one school district and the results may therefore be nested in the environment.

5. The subject's knowledge that he was participating in an experiment may have differentially affected the group's responses. If the experiment were conducted as a part of a classroom activity, perhaps the results would have been different.

6. The task may have been too difficult and therefore masked recall differences and/or discouraged the use of acquisition and retrieval strategies.

7. The accuracy of the apparatus was not compared to another and therefore there was no assurance that the timing and recording mechanisms were reliable at the time of the experiment.

8. There was insufficient data to analyze the retrieval strategy from each serial position.

9. There was a disproportionately large number of third grade subjects that were eligible for this study. This might have been due to the selection process, or the fact that the third grade group simply had less training than the fifth or seventh grades.

Implications for Further Research

Despite the findings of the present study, Belmont's and Butterfield's (1969) short - term memory (STM) model and research procedures may provide a fruitful paradigm for future research with reading disabled youngsters. Since no differences were found between reading disabled and normal subjects' recall accuracy, acquisition strategies and retrieval processes, continued research is necessary to insure that these findings were not a function of variables unique to the present study. For example, future studies might reduce the number of letters in the serial list from eight to six items, or use of a different stimulus item, e.g., pictures, short words or line drawings, which might provide different results. Future research may vary the response requirement from recall of a single item to total recall of items in a forward, backward or circular order.

If, however, future research continues to support the findings of the present study, and concludes that reading disabled children are not deficient in STM processing, the research paradigm used in this study may still be useful in studying the following questions:

1. Does manipulation of various stimulus dimensions of the material (e.g., Zeaman - House Attention Theory [1963]) alter recall accuracy, acquisition strategies or retrieval processes?

2. If rewards provided for correct responses increase the probability of future correct responses, does this affect the individual's acquisition and retrieval processes?

3. What sort of training will most efficiently increase correct recall? Will it center on methods that manipulate stimuli such as programmed instruction and stimulus reduction, or methods that manipulate the response consequences such as operant methodology and behavior modification techniques? Or, will new training techniques which modify acquisition and retrieval processes be the most effective way

to increase correct recall? Perhaps the best method would be some sort of combination of all the above suggested techniques. At any rate, Belmont's and Butterfield's (1969) techniques can be used to investigate the effeciency of various training approaches.

4. Are there acquisition and retrieval strategies which are effective in altering STM and make the subject "appear" to be learning but which actually interfere with long - term retention?

5. Will improved STM lead to more effective long - term memory?

6. Do acquisition, retrieval and/or recall accuracy vary as a result of various modality presentations (e.g., auditory and visual) and response modes (e.g., verbal and motor)?

As can be seen by the above examples, the present research generated more questions than answers. The present research failed to find STM deficits in reading disabled subjects, however, it did provide results and generate questions which may be useful in future studies designed to gather further information on reading disabled children.

BIBLIOGRAPHY

BIBLIOGRAPHY

Books

Austin, M. C., Bush, C. L., & Huebner, M. H. Reading evaluation. New York: Ronald Press, 1961.

Belmont, J. M. and Butterfield, E. C. The relationship of short - term memory to development and intelligence. In L. P. Lipsitt and H. W. Reese (Eds.), Advances in child development and behavior. Volume 4. New York: Academic Press, 1969.

Betts, E. A. Foundation of reading instruction. New York: American Book Company, 1950.

Broadbent, D. E. Perception and communication. London: Pergamon Press, 1958.

de Hirsch, K., Jansky, J. J., & Langford, W. S. Predicting reading failures, a preliminary study. New York: Harper and Row, 1966.

Dixon, W. G. (Ed.), BMD Biomedical Computer Programs. Los Angeles: University of California Press, 1968. Second Edition.

Ellis, N. R. The stimulus trace and behavioral inadequacy. In N. R. Ellis (Ed.), Handbook of Mental Deficiency. New York: McGraw - Hill Book Company, 1963. pp. 134-158.

Ellis, N. R. Memory processes in retardates and normals. In N. R. Ellis (Ed.), International review of research in mental retardation. Volume 4. New York: Academic Press, 1970. pp. 1-32.

Fernald, G. M. Remedial techniques in basic school subjects. New York: McGraw - Hill Book Company, 1943.

Frostig, M. Teaching reading to children with perceptual disturbances. In R. M. Flower, H. F. Gofman, & L. I. Lawson (Eds.), Reading disorders. Philadelphia, 1965. pp. 113-127.

Harris, A. J. Influence of individual differences on the reading program. In H. A. Robinson (Ed.), Meeting individual differences in reading. Chicago: Supplementary Educational Monographs, 1964.

Harris, A. J. Individual first - grade reading according to specific learning aptitudes. Research Report, Office of Research and Evaluation. New York: The City University of New York, 1965.

Harris, A. J. How to increase reading ability. New York: David McKay Company, 1970. Fifth Edition.

Hebb, D. O. The organization of behavior. New York: John Wiley and Sons, 1949.

Hilgard, E. R. and Bower, G. H. Theories of learning. New York: Appleton - Century Crofts, 1966. Third Edition.

Johnson, O. J. and Myklebust, H. R. Learning disabilities: Educational principles and practices. New York: Grune and Stratton, 1967.

Kirk, S. A. Educating exceptional children. Boston: Houghton Mifflin Company, 1962.

Montessori, M. The Montessori method. New York: Frederick A. Stokes Company, 1912.

Muller, G. E. and Pilzecker, A. Experimentelle beitage zur lehre vom gedachtnis, Z. Psychol., Ergbd, I, 1900. In E. H. Hilgard and G. H. Bower (Eds.), Theories of learning. New York: Appleton - Century - Crofts, 1966. Third Edition.

Neville, D. The intellectual characteristics of severely retarded readers and implications for teaching techniques in learning disorders. In J. Hellmuth (Ed.), Learning disorders. Volume 2. Seattle: Bernie Straub and Jerome Hellmuth Company, publishers, Special Child Publications, 1966.

Norman, D. A. Memory and attention. New York: John Wiley and Sons, 1969.

Pavlov, I. P. Conditioned reflexes. New York: Oxford University Press, 1927.

Scott, K. G. and Scott, M. S. Research and theory in short - term memory. In N. R. Ellis (Ed.), International review of research in mental retardation. Volume 3. New York: Academic Press, 1968.

Senf, G. M. Development of immediate memory for bi-sensory stimuli in normal children and children with learning disorders. In B. R. McCandles (Ed.), Developmental psychology monograph, 1969. Volume 1. pp. 1-28.

Smith, R. M. Clinical teaching: Methods of instruction for the retarded. New York: McGraw - Hill Book Company, 1968.

Sperling, G. A. Successive approximations to a model for short - term memory. In A. F. Sanders (Ed.), Attention and performance. Amsterdam: North Holland Publishing Company, 1967. (A special edition of Octa Psychologica, Volume 27.)

Spitz, H. H. Field theory in mental deficiency. In N. R. Ellis (Ed.), Handbook of mental deficiency. New York: McGraw - Hill Book Company, 1963.

Strauss, A. A. and Lehtinen, L. E. Psychopathology and education of the brain - injured child. New York: Grune and Stratton, 1947.

Wepman, J. M. The perceptual basis for learning. In E. C. Frieson and W. B. Barbe (Eds.), Educating children with learning disabilities: Selected readings. New York: Appleton - Century - Crofts, 1967.

Wepman, J. M. The modality concept: Including a statement on the perceptual and conceptual levels of learning. In H. K. Smith (Ed.), Perception and Reading. Newark, New Jersey: International Reading Association, 1968.

Zeaman, D. and House, B. J. The role of attention in retardate discrimination learning. In N. R. Ellis (Ed.), Handbook of mental deficiency. New York: McGraw - Hill Book Company, 1963. pp. 159-233.

Periodicals

Alwitt, L. F. Decay of immediate memory for visually presented digits among nonreaders and readers. Journal of Experimental Psychology, 1963, 34.

Bannatyne, A. Diagnostic learning disabilities and writing remedial prescriptions. Journal of Learning Disabilities, 1968, 1, 242-249.

Bateman, B. Implications of a learning disability approach for teaching educable retardates. Mental Retardation, 1967, 5, 23-25.

Bateman, B. Three approaches to diagnosis and educational planning for children with learning disabilities. Academic Therapy Quarterly, 1967, 2. (a)

Bateman, B. The efficacy of an auditory and a visual method of first grade reading instruction with auditory and visual learners. Curriculum Bulletin, 1967, 23, 6-14. (b)

Beery, L. E. Matching of auditory and visual stimuli by average and retarded readers. Child Development, 1967, 38, 827-833.

Birch, H. G. and Belmont, L. Auditory - visual integration in normal and retarded readers. American Journal of Orthopsychiatry, 1964, 34, 852-861.

Blankenship, A. B. Memory span: A review of the literature. Psychological Bulletin, 1938, 35, 1-25.

Bond, G. L. and Dykstra, G. Final report of the coordinating center for first grade reading instructional programs. U.S.O.E., Project X -001. University of Minnesota, Minneapolis, 1967.

Bruininks, R. H. Teaching word recognition to disadvantaged boys. Journal of Learning Disabilities, 1970, 3, 30-39.

Butterfield, E. C. and Belmont, J. M. Relations of storage and retrieval strategies as short - term memory processes. Journal of Experimental Psychology, 1971, 89, 2, 319-328.

Chalfant, J. C. and Scheffelin, M. A. Central processing dysfunction in children: A review of research. National Institute of Neurological Diseases and Stroke, Public Health Services, National Institute of Health, U.S. Department of Health, Education and Welfare. Bethesda, Maryland, 1969.

Cohn, R. The neurological study of children with learning disabilities. Exceptional Children, 1964, 31, 179-185.

Denison, J. W. Perceptual influences in the primary grades: An alternative consideration. Journal of School Psychology, 1968-69, 1, 38-46.

Dornbush, R. L. and Basow, S. The relationship between auditory and visual short - term memory and reading achievement. Child Development, 1970, 41, 1033-1044.

Durrell, D. D. and Murphy, H. A. The auditory discrimination factor in reading readiness and reading disability. Education, 1953, 73, 556-560.

Ellis, N. R. and Dugas, J. Serial position effect in short - term memory under E and S paced condition. Psychonomic Science, 1968, 12, 2, 55-56.

Goldstein, H. Mentally retarded children in special programs. Journal of Education, 1964, 147, 95-100.

Johnson, M. S. Factors related to disability in reading. Journal of Experimental Education, 1957, 26.

Katz, P. A. and Deutsch, M. Modality of stimulus presentation in serial learning for retarded and normal readers. Perceptual and Motor Skills, 1964, 19, 627-633.

McCarthy, J. J. The importance of linguistic ability in the mentally retarded. Mental Retardation, 1964, 2, 90-96.

Mills, R. E. An evaluation of techniques for teaching word recognition. The Elementary School Journal, 1956, 56, 221-225.

Muehl, S. and Kremenak, S. Ability to match information within and between auditory and visual sense modalities and subsequent reading achievement. Journal of Educational Psychology, 1966, 57, 230-239.

Pinkus, A. L. and Laughery, K. P. Recoding and grouping processes in short - term memory: Effects of subject - paced presentation. Journal of Experimental Psychology, 1970, 35, 335-341.

Rose, F. C. The occurrence of short auditory memory span among school children referred for diagnosis of reading difficulties. Journal of Educational Resources, 1958, 51, 459-464.

Rudisill, M. Flashed digit and phrase recognition of oral and concrete responses: A study of advanced and retarded readers in third grade. Journal of Psychology, 1956, 42, 317-328.

Van DeMoortel, R. Immediate memory span in children: A review of the literature. Report No. 1, May 1, 1965, University of Michigan Center for Human Growth and Development, Grant No. 1 PO1 HDO1368 - 01, National Institute for Child Health and Human Development.

Waugh, N. C. and Norman, D. A. Primary memory. Psychological Review, 1965, 72, 89-104.

Wolpert, E. M. Modality and reading: A perspective. The Reading Teacher, 1971, 24, 640-643.

Unpublished Material

Butterfield, E. C., Wambold, C. & Belmont, J. M. On the theory and practice of improving short - term memory in the retarded. Unpublished manuscript, Kansas Center for Research in Mental Retardation, University of Kansas and Yale University, 1972. (Manuscript currently in press. Accepted for publication by American Journal of Mental Deficiency.)

Tyler, J. L. Modality preference and reading task performance among the educable mentally retarded. Unpublished doctoral dissertation, University of Kansas, 1971.

Wolpert, E. M. Individual differences in sensory modality functioning in first grade children in learning to read common words of two imagery values. Unpublished doctoral dissertation, University of Kansas, 1970.

Tests

Kelly, T., Madden, R. & Gardner, E. F. Stanford Achievement Test. New York: Harcourt, Brace and World, 1966.

Otis, A. S. and Lennon, R. T. Otis - Lennon Mental Ability Test. New York: Harcourt, Brace and World, 1967.

APPENDIX A

RAW DATA ON THIRD, FIFTH AND SEVENTH GRADE READING DISABLED AND NORMAL SUBJECTS

RAW DATA ON THIRD GRADE READING DISABLED SUBJECTS

Subject Identification	Chronological Age	IQ	Percentile Rank: Word Meaning	Percentile Rank: Paragraph Meaning	Percentile Rank: Word Study	Reading Grade Level: Word Meaning	Reading Grade Level: Paragraph Meaning	Reading Grade Level: Word Study	Reading Grade Level: X̄ Reading Level
301	8.17	100	20.3	6.2	18.3	2.6	1.9	2.1	2.20
302	10.17	96	26.4	10.2	2.1	2.7	2.1	1.4	2.07
303	9.33	104	16.3	4.2	8.2	2.5	1.8	1.7	2.00
304	8.92	109	8.2	4.25	2.1	2.0	3.0	1.4	2.13
305	8.33	97	20.3	6.2	34.4	2.6	1.9	2.6	2.37
306	9.92	98	6.2	20.3	26.4	1.9	2.5	2.4	2.27
307	8.92	74	4.2	4.2	20.3	1.8	1.8	2.2	1.93
308	9.08	94	6.2	8.2	16.3	1.9	2.0	2.0	1.97
309	9.50	100	6.2	14.3	12.3	1.9	2.3	1.9	2.03
310	8.17	103	8.2	16.3	34.4	2.0	2.4	2.7	2.37

Recall Accuracy — Serial Position

Subject Identification	1	2	3	4	5	6	7	8
301	2	0	3	2	3	1	1	0
302	0	0	0	3	1	2	2	3
303	0	1	0	0	1	1	4	2
304	0	0	2	1	0	3	4	1
305	0	0	1	2	2	1	2	4
306	3	2	0	0	3	1	0	2
307	2	0	2	0	0	2	0	4
308	1	1	1	0	0	0	1	2
309	1	1	0	2	1	2	2	3
310	1	1	0	2	1	2	2	2

Interitem Interval — Serial Position

Subject Identification	1	2	3	4	5	6	7	8
301	1875	1850	1850	1950	1875	1925	1875	1900
302	2475	2500	2450	2250	2325	2425	2600	2300
303	1275	1475	1600	1550	1425	1450	1425	1200
304	1825	1525	1575	1475	1375	1400	1525	1425
305	1875	1950	[illegible]	2050	1875	1975	2025	1775
306	1450	2250	2550	2375	2175	2125	2100	1850
307	2125	2150	2150	2225	2250	2375	2250	2075
308	1575	1725	1575	1600	1525	1675	1600	1375
309	1725	1725	1800	1725	1800	1775	1775	1500
310	2400	2575	2825	2650	2650	2650	2475	2325

Correct Recall Latency — Serial Position

Subject Identification	1	2	3	4	5	6	7	8
301	2.345		5.160	2.140	1.960	1.220	3.660	
302				1.920	1.960	1.660	1.770	1.330
303		1.420			2.900	2.650	1.465	2.525
304			3.020	4.530		1.950	1.700	2.055
305			4.530	2.505	2.215	2.460	2.410	1.310
306	2.310	4.185			3.620	3.520		1.740
307	5.585		5.430			7.200	1.810	1.335
308	1.830	1.830	4.020				2.100	1.935
309	2.230	1.040		5.879	4.760	4.490	2.530	1.600
310		4.120		2.680		10.599	2.335	1.579

RAW DATA ON THIRD GRADE NORMAL SUBJECTS

Subject Identification	Chronological Age	IQ	Percentile Rank: Word Meaning	Percentile Rank: Paragraph Meaning	Percentile Rank: Word Study	Reading Grade Level: Word Meaning	Reading Grade Level: Paragraph Meaning	Reading Grade Level: Word Study	Reading Grade Level: X̄ Reading Level
311	7.92	102	62.6	54.5	90.8	3.5	3.2	6.0	4.23
312	9.08	93	86.7	86.7	99.9	4.2	4.3	7.2	5.23
313	8.50	100	74.6	14.8	86.7	3.7	5.0	5.6	4.77
314	9.67	90	90.8	62.6	72.6	4.4	3.4	6.5	4.77
315	8.50	98	62.6	68.6	30.4	3.5	3.6	2.5	3.20
316	8.50	102	62.6	50.5	16.3	3.5	3.1	2.0	2.87
317	9.58	105	96.9	68.6	80.7	5.1	3.6	5.0	4.57
318	8.08	110	56.5	80.7	82.7	3.3	4.0	5.2	4.17
319	8.67	108	96.9	90.8	92.8	5.1	4.6	6.3	5.33
320	8.25	93	90.8	54.5	12.3	4.4	3.2	1.9	3.17

Recall Accuracy

Subject Identification	Serial Position 1	2	3	4	5	6	7	8
311	0	1	0	2	0	2	2	4
312	0	0	0	1	1	1	3	4
313	0	0	0	1	0	3	1	2
314	2	1	1	2	1	0	1	3
315	0	0	0	1	0	3	2	4
316	2	0	2	3	3	2	1	3
317	2	2	0	0	0	0	3	4
318	2	1	0	1	1	1	2	0
319	1	0	0	2	1	0	1	3
320	1	1	0	0	1	1	3	3

Interitem Interval

Subject Identification	Serial Position 1	2	3	4	5	6	7	8
311	1450	1625	1775	1700	1775	1850	1900	1675
312	2200	2250	2300	2300	2175	2150	2075	1725
313	2125	2175	2950	2950	2150	3050	3025	2175
314	2300	2450	2325	2200	2400	2300	3350	2000
315	1250	1050	1075	1000	1000	1025	975	950
316	1225	1375	1350	1350	1325	1275	1225	975
317	1725	1800	1850	1875	1775	1725	1800	1525
318	1675	1800	2100	2000	1950	2050	2025	1775
319	1825	1800	1800	2050	1975	2100	1775	1775
320	1175	1075	1000	1075	1025	1025	1075	925

Correct Recall Latency

Subject Identification	Serial Position 1	2	3	4	5	6	7	8
311	--	2.710	--	2.570		2.205	1.285	.965
312				2.300	1.770	3.010	1.310	1.825
313				2.680		1.670	2.120	1.525
314	2.845	0.880	3.430	3.630	5.085		1.040	3.555
315				4.009		1.130	.910	1.315
316	1.560		1.515	1.760	1.960	3.340	.920	1.800
317	3.530	3.020					1.570	1.520
318	1.285	5.460		3.770	3.620	2.030	1.535	
319	2.300			1.455	1.110		1.890	.920
320	3.550		3.430		1.690	2.190	1.440	1.800

RAW DATA ON FIFTH GRADE READING DISABLED SUBJECTS

Subject Identification	Chronological Age	IQ	Percentile Rank: Word Meaning	Percentile Rank: Paragraph Meaning	Percentile Rank: Word Study	Reading Grade Level: Word Meaning	Reading Grade Level: Paragraph Meaning	Reading Grade Level: Word Study	Reading Grade Level: $\bar{X}$ Reading Level	Recall Accuracy 1	Recall Accuracy 2	Recall Accuracy 3	Recall Accuracy 4	Recall Accuracy 5	Recall Accuracy 6	Recall Accuracy 7	Recall Accuracy 8	Interitem Interval 1	Interitem Interval 2	Interitem Interval 3	Interitem Interval 4	Interitem Interval 5	Interitem Interval 6	Interitem Interval 7	Interitem Interval 8	Correct Recall Latency 1	Correct Recall Latency 2	Correct Recall Latency 3	Correct Recall Latency 4	Correct Recall Latency 5	Correct Recall Latency 6	Correct Recall Latency 7	Correct Recall Latency 8
501	10.5	99	24.4	14.3	20.3	4.1	3.6	3.1	3.6	3	2	3	2	1	0	3	1	1950	2025	2025	1975	2125	2075	1975	1875	1.290	1.550	1.930	3.725	1.010		1.440	1.100
502	10.67	96	32.4	20.3	20.3	4.4	3.9	3.1	3.8	1	1	1	1	1	0	1	4	2125	3800	4125	3675	4300	4200	3775	3600	1.560	5.520	3.920	2.780	4.450		2.900	1.335
503	10.33	101	18.3	12.3	20.3	3.8	4.8	3.1	3.9	1	2	0	1	0	0	2	4	1600	1750	1650	1525	1775	1675	1675	1350	1.680	1.570		1.950			1.295	1.115
504	10.33	97	18.3	6.2	16.3	2.8	3.0	2.9	2.9	1	2	1	1	1	3	2	4	1675	1500	1650	1825	1675	1575	1400	1350	2.230	2.225	5.660	4.440	3.370	5.620	5.330	1.415
505	10.17	104	50.5	6.2	28.4	5.1	2.9	3.6	3.87	0	0	1	0	0	2	2	4	2175	3325	2200	3100	2025	2000	1925	1475			3.770			1.765	1.325	1.350
506	10.55	91	8.2	16.3	1.1	3.3	3.7	2.1	3.03	1	2	0	0	1	1	4	3	1650	1600	1650	1500	1450	1550	1440	1350	4.210	3.790			1.560	10.740	1.915	2.270
507	10.17	105	24.4	10.5	16.3	4.1	4.7	2.9	3.90	0	2	0	2	1	1	1	3	2375	3400	2500	2500	2550	2550	2500	2075		1.895		3.325	3.020	1.580	1.900	1.830
508	10.25	101	40.5	2.1	8.2	4.7	2.5	2.6	3.27	1	0	1	1	1	0	1	2	1875	1875	1825	1800	1725	1725	1675	1425	1.400		1.440	1.430	1.120		1.020	1.265
509	10.25	93	24.4	11.3	2.1	4.1	3.4	2.3	3.27	4	1	2	1	1	1	2	3	1425	1550	1475	1500	1500	1425	1500	1325	2.945	2.550	2.075		1.210	5.110	1.549	1.180
510	10.67	91	12.3	2.1	4.2	3.6	2.6	2.4	2.87	0	0	1	0	0	0	2	3	1925	1775	1750	1750	1825	1925	1975	1975			1.980				2.470	2.640

RAW DATA ON FIFTH GRADE NORMAL SUBJECTS

Subject Identification	Chronological Age	IQ	Percentile Rank: Word Meaning	Percentile Rank: Paragraph Meaning	Percentile Rank: Word Study	Reading Grade Level: Word Meaning	Reading Grade Level: Paragraph Meaning	Reading Grade Level: Word Study	Reading Grade Level: X̄ Reading Level
511	10.8	102	65.6	58.5	76.7	5.7	5.4	6.5	5.87
512	10.9	105	74.6	70.6	30.4	5.9	6.0	5.7	5.87
513	10.0	103	48.6	56.5	44.5	5.7	5.3	4.6	5.20
514	11.4	101	68.6	68.7	59.5	5.7	6.9	5.3	5.97
515	10.4	106	78.7	82.7	77.7	6.1	6.7	6.7	6.5
516	10.3	107	78.7	2.1	56.5	6.1	2.6	5.5	4.73
517	10.7	103	92.8	82.8	70.6	7.3	7.5	7.6	7.47
518	11.1	109	36.7	79.6	70.6	6.7	6.1	6.3	6.37
519	10.9	109	78.7	77.7	89.8	6.1	6.3	7.3	6.57
520	10.3	109	66.6	64.6	56.5	5.6	5.7	5.5	5.6

Recall Accuracy — Serial Position

Subject Identification	1	2	3	4	5	6	7	8
511	2	3	1	2	0	2	1	2
512	0	1	2	0	0	1	3	4
513	0	0	1	0	1	0	2	2
514	0	1	2	2	0	1	4	4
515	0	0	1	0	0	2	4	4
516	0	4	0	1	1	0	2	1
517	0	1	0	2	0	1	3	4
518	4	3	1	2	3	1	1	3
519	2	0	1	2	1	0	0	2
520	2	2	3	1	0	1	3	4

Interitem Interval — Serial Position

Subject Identification	1	2	3	4	5	6	7	8
511	2175	2200	2175	2200	2425	2225	2125	1925
512	2000	1825	2050	3075	2025	2000	1925	1800
513	2225	2325	2350	2375	2325	2200	2250	1925
514	2225	2350	2425	2325	3225	3275	2200	1850
515	1825	1950	1950	2000	1950	1925	3075	1900
516	1275	1625	1700	1750	1675	1775	1775	1425
517	2600	2750	2450	2900	2850	2600	2050	1950
518	3525	2100	2450	3350	3525	4825	2675	4050
519	1925	1925	1925	2025	1925	1925	1925	1925
520	2125	2525	2525	2700	2825	2850	3125	2625

Correct Recall Latency — Serial Position

Subject Identification	1	2	3	4	5	6	7	8
511	1.280	1.700	2.040	1.425		1.235	1.280	2.095
512		.890	1.660			1.810	1.300	.925
513			3.000		.950		1.235	1.685
514		2.350	1.605	1.375		1.410	1.210	1.350
515			2.660			3.080	1.635	1.690
516		1.630		1.380	7.010		1.165	1.170
517		1.880		2.380		1.770	1.040	1.765
518	1.885	2.900	3.680	4.510	2.490	6.330	5.220	1.470
519	1.540		2.760	2.265	1.760			1.580
520	2.235	3.260	3.600	4.550		4.160	2.500	1.770

RAW DATA ON SEVENTH GRADE READING DISABLED SUBJECTS

Subject Identification	Chronological Age	IQ	Percentile Rank: Word Meaning	Percentile Rank: Paragraph Meaning	Percentile Rank: Word Study	Reading Grade Level: Word Meaning	Reading Grade Level: Paragraph Meaning	Reading Grade Level: Word Study	Reading Grade Level: $\bar{X}$ Reading Level
701	12.92	94		1.1			2.5		
702	12.33	98		18.3			5.2		
703	13.5	97		6.2			4.0		
704	11.75	100		18.3			5.2		
705	12.92	100		20.3			5.4		
706	11.83	94		23.4			5.6		
707	12.58	91		6.2			4.0		
708	13.42	103		14.3			5.4		
709	13.5	100		14.3			5.0		
710	12.25	105		2.1			3.2		

Recall Accuracy — Serial Position

Subject	1	2	3	4	5	6	7	8
701	0	1	1	1	2	1	2	4
702	1	0	3	0	2	0	2	1
703	0	1	1	2	0	0	4	4
704	1	0	2	2	0	1	2	1
705	0	0	1	0	1	1	1	3
706	1	0	1	0	0	0	1	4
707	2	1	0	0	2	0	0	3
708	0	1	0	0	0	0	1	4
709	0	1	0	1	1	3	4	4
710	2	1	0	1	1	0	2	3

Interitem Interval — Serial Position

Subject	1	2	3	4	5	6	7	8
701	1675	1675	1675	1575	1650	1550	1550	1425
702	1825	1875	1850	1850	1825	1850	1800	1775
703	1675	1700	1825	1825	1900	1775	1850	1725
704	2175	2175	2300	2225	2125	2150	2150	1950
705	1000	1025	975	1000	1075	1000	975	825
706	1725	1625	1625	1800	1800	1850	1800	1625
707	1800	1825	1850	1825	1925	1900	1925	1650
708	1100	1050	1125	925	925	1000	925	900
709	1775	1625	1625	1325	1525	1625	1550	1425
710	2050	2300	2350	2250	2225	2300	2150	1850

Correct Recall Latency — Serial Position

Subject	1	2	3	4	5	6	7	8
701		1.080	3.410	4.720	3.700	2.540	1.250	1.055
702	2.260		1.690		1.730		1.265	1.500
703		1.040	1.330	1.395			1.350	1.035
704	2.460		3.080	2.705		1.490	1.535	1.800
705			1.860		1.620	1.600	1.240	1.160
706	2.080		2.850				1.230	1.530
707	2.205	2.080	—			2.520		1.290
708		2.060					1.300	1.165
709		2.380		2.530	1.090	1.400	1.140	1.010
710	6.780	5.640		1.720	1.850		3.655	1.640

RAW DATA ON SEVENTH GRADE NORMAL SUBJECTS

Subject Identification	Chronological Age	IQ	Percentile Rank: Word Meaning	Percentile Rank: Paragraph Meaning	Percentile Rank: Word Study	Reading Grade Level: Word Meaning	Reading Grade Level: Paragraph Meaning	Reading Grade Level: Word Study	Reading Grade Level: $\bar{X}$ Reading Level	Recall Accuracy Serial Position 1	2	3	4	5	6	7	8	Interitem Interval Serial Position 1	2	3	4	5	6	7	8	Correct Recall Latency Serial Position 1	2	3	4	5	6	7	8
711	13.25	103		58.5			7.6			0	3	2	2	0	1	2	2	1725	1675	1775	1750	1650	1475	1825	1825		3.880	3.490	2.030		1.890	1.940	1.355
712	12.67	104		58.5			7.6			1	0	1	0	0	1	2	4	1000	1050	1050	1050	1000	1050	1025	975	2.690		3.260			2.810	2.280	1.260
713	11.92	102		50.5			7.0			1	1	0	0	0	1	4	4	2300	2125	2100	2100	2025	2050	1900	1475	1.480	1.510				1.080	1.345	1.075
714	12.25	103		84.7			10.0			4	2	1	1	2	2	4	4	1100	1150	1175	1125	1200	1175	1125	1025	2.150	2.635	2.610	5.220	3.380	2.220	1.615	1.250
715	11.83	102		54.5			7.4			0	2	0	0	0	1	2	4	975	1025	1025	1025	1075	1025	1000	950		1.380				1.180	1.085	1.130
716	13.0	109		52.5			7.2			2	1	1	0	0	1	3	3	2100	2250	2350	2250	2300	2250	2375	1925	1.355	3.100	5.270			3.130	1.330	1.340
717	12.42	106		84.7			10.0			0	0	0	0	1	1	3	3	1800	1825	1800	1775	1750	1725	1625	1500					1.760	1.440	1.370	1.190
718	12.55	107		70.6			8.2			0	0	0	2	0	2	3	4	1275	1300	1350	1350	1350	1425	1325	1275				2.260		1.670	1.540	1.265
719	12.17	105		58.5			7.6			3	4	3	2	0	1	1	3	1175	1300	1275	1500	1375	1325	1275	1050	1.530	1.420	1.590	2.085		1.690	1.010	2.150
720	13.42	108		64.6			7.8			0	2	1	2	2	0	2	4	950	850	900	875	925	900	925	925		2.125		2.625	1.880		1.445	1.315

APPENDIX B

SAMPLE EIGHT LETTER LIST

P - 1

Example of List

Ⓡ

K

V

P

Z

Q

H

J

R

APPENDIX C

PRELIMINARY INSTRUCTIONS

PRELIMINARY INSTRUCTIONS

We are interested in how well you can remember a list of letters. I'd like you to read these letters for me. (Subject was shown a card with a list of the letters used in this study.) When you press this button, you will see a letter come on here, when you press the button again you will see a letter come on here, and each time you press the button, you will see a letter come on in each of these windows. The last time you press the button, a letter with a circle around it will come on here. (DEMONSTRATE each step to subject.) Your job is to remember where you saw the letter that matches the letter with the circle around it, and press the window where you saw it. DEMONSTRATE.

If you saw the letters A J L and J came on here, which window would you press? Good! (If subject does not press the correct window, show him the correct one.)

Do not begin until you see a black square in the first window. Try to remember all of the letters and try to do your best.

APPENDIX D

LIST OF TWELVE LETTERS USED IN STUDY

H X N Z W J Q V L P R K

APPENDIX E

THIRTY - TWO, EIGHT ITEM LISTS GROUPED IN FOUR BLOCKS

Number:
E or C:
Data:

					R	Latency	
1	KQZPHVNL		V - 6				
2	JZRKWPLN		R - 3				
3	PHJKXQVL		L - 8				
4	NKHJXRLV		N - 1				BLOCK 1
5	RNXQZHWL		Z - 5				
6	WQPLJVXZ		X - 7				
7	ZWKLXQPJ		W - 2				
8	HXLJQPRV		J - 4				
1	RLQPVWXN		Q - 3				
2	LKXWRZQJ		Z - 6				
3	LWXKPZVJ		P - 5				
4	HXQNKWJR		R - 8				BLOCK 2
5	PKNLHVXJ		K - 2				
6	WQVRHNKJ		R - 4				
7	PWVXHNJQ		P - 1				
8	VXKLQWZP		Z - 7				
1	HPXRQWKJ		P - 2				
2	WJLRKXPZ		X - 6				
3	XRJVZHPW		J - 3				
4	LWJNQRPX		X - 8				BLOCK 3
5	KQZPJNWX		W - 7				
6	KNLWVQPZ		V - 5				
7	KVQHNRXL		K - 1				
8	XLHJVQRP		J - 4				
1	VZKQLNWH		H - 8				
2	VPXWNHJK		X - 3				
3	XPWRJQNH		P - 2				
4	LPHNKQXW		N - 4				BLOCK 4
5	XPWRZVQH		X - 1				
6	NQKJHWPV		W - 6				
7	PNJZWQVL		V - 7				
8	RQPJHXKW		H - 5				