February 11, 1974

To the Graduate Council:

I am submitting herewith a thesis written by Hiram Lonsdale McDade III entitled "An Evaluation of Methods for Testing Auditory Retention Abilities of Moderately Retarded Mongoloid Subjects." I recommend that it be accepted for nine quarter hours of credit in partial fulfillment of the requirements for the degree of Master of Arts, with a major in Speech Pathology.

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173

AN EVALUATION OF METHODS FOR TESTING AUDITORY RETENTION ABILITIES OF MODERATELY RETARDED MONGOLOID SUBJECTS

A Thesis

Presented for the

Master of Arts

Degree

The University of Tennessee

Hiram Lonsdale McDade III

March 1974

ACKNOWLEDGMENTS

The writer wishes to express his sincere gratitude to the committee, Dr. Sol Adler, Dr. Carl Asp, and Dr. Carmen Lozzio, for their careful guidance and encouragement in the direction of this thesis. Appreciation is also extended to Ora Henson and the entire staff at the Birth Defects Center for their support and understanding throughout the preparation of this thesis.

A special note of thanks is offered to the writer's wife, Carol, whose encouragement, optimism, and indeed, patience played a vital role in the completion of this study.

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ABSTRACT

The purpose of this study was to investigate the auditory retention abilities of two groups of moderately retarded mongoloid subjects. Thirteen subjects were selected and grouped according to their mucopolysaccharide (MPS) level; high MPS subjects comprising group one, with normal MPS subjects representing group two. All subjects were patients at the Birth Defects Evaluation Center at The University of Tennessee Memorial Hospital and Research Center. They were between the ages of 5-0 and 12-6, had I.Q. scores between 36 and 51 (moderate range of mental retardation), possessed normal hearing acuity, and were genetically diagnosed as having Trisomy 21, Down's Syndrome.

Each subject received a battery of five standardized auditory memory tests: (1) the digit span test from the W.I.S.C., (2) the digit span test from the Stanford-Binet, (3) the digit span test from the I.T.P.S., (4) the unrelated words test from The Detroit Tests of Learning Aptitude, and (5) the oral commissions test also from the Detroit. Each test was administered twice, differing the second time in presentation rate only (one item per second versus two items per second). All raw scores were converted into mental age equivalents and treated statistically.

The results from this study revealed that subjects scored significantly higher on the oral commissions test than on any of the other tests. Only one of the 13 subjects was able to perform on the digits backwards portion of the W.I.S.C. digit span test. The other

12 were unable to achieve the minimum score on this test. Of the remaining four short-term memory tests, only the unrelated words test failed to correlate highly with both the Peabody and Stanford-Binet mental age scores. Presentation rate was found to have no significant effect upon recall ability. No significant difference was found between high and normal MPS subjects. An analysis of serial position curves revealed that these subjects tended to recall only the last few items in unrelated word sequences which were beyond their initial memory spans. This recency effect did not appear to be influenced by presentation rate. It was also discovered that the number of unrelated items which could be recalled by these subjects remained fixed irrespective of the length or number of items in the stimuli. If syntactically organized stimuli were presented, however, the order of recall (as in the oral commissions test) indicated a primacy trend (that is, the first items presented were remembered best).

In general, the meaningfulness between test items (that is, the inter-item associations) appeared to have a greater effect on recall than the actual meaning of each individual item.

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CHAPTER I

INTRODUCTION

It has long been contended that short-term memory--more specifically, auditory retention--is an underlying problem with language retarded children. According to Scott (1968, p. 136):

> The ability to hold information in short-term memory may be a critical skill in most learning and problem solving situations. . . . The fact that a memory span is limited suggests that an individual with a brief span may lose much incoming information before he is able to process it into long-term memory. . . . A poor short-term memory may therefore reduce the probability that a given piece of information is permanently stored.

Memory span, in general, has been measured since 1885 (Ebbinghaus). Up to, and including the present, most studies have utilized the technique of recall for evaluating short-term memory skills. One of the oldest, most frequently utilized, and probably most highly criticized tests available for assessing auditory short-term memory abilities is the digit span test. Van Riper (1949) determined that a five-year-old child with normal intelligence should be able to retain up to four digits, while Miller (1956) discovered that the average adult can recall as many as seven digits (plus or minus two) at least 50 percent of the time. While such tests have become a standard item on most verbal intelligence scales, their critics continue to contend that the recall of random, unrelated, nonpropositional units is not comparable to the highly structured propositionality of language. And, as Adler (1970, p. 133) has suggested, an impaired ability to retain such sequential presentations of digits ". . . does not

necessarily imply an impaired ability to retain sequential language units."

Graham (1968), in an attempt to utilize stimuli with a higher degree of propositionality for evaluating short-term memory, devised a test which demanded the recall of strings of words. These non-sentence sequences ranged in length from two to six words. He concluded that "The range of sentence types which can be used by these children (educable subnormal) was restricted by their memory span." Miller (1962) conducted a study which demanded the recall of various syntactical structures (kernal sentences versus sentences involving transformations). His theory, like that of Graham, was that a memory span deficit may interfere with the rules needed to understand sentence structure. When utilizing sentences, however, it must be remembered that what is actually being tested is a subject's long-term memory for transformational rules and not his short-term memory, per se.

The Detroit Tests of Learning Aptitude (first developed in 1935 and revised in 1959) employ both the recall of unrelated words and the performance of various one to four-part commissions. Having been administered to over 4000 mentally retarded children, it is believed to be a suitable means for assessment of the retarded population (Baker and Leland, 1967).

In short, while there appears to be little disagreement over the assumption that deficits in auditory retention can impair language and general learning ability, a major conflict in views occurs when attempting to determine which type of test (stimuli) should be utilized. It appears critical, therefore, that we find an accurate, meaningful,

and reliable means for evaluating a given child's auditory retention abilities regardless of his level of intelligence of language ability. The test(s) utilized in making such an assessment must, in some manner, relate to language characteristics if a correlation between the two (short-term memory and language) is to be demonstrated.

The converse of this premise would seem to imply that mentally retarded individuals have brief short-term memory spans, and this is exactly what most studies appear to indicate. Baroff (1959) found, on the W.I.S.C., that digit span was a test of intermediate difficulty for moderately retarded children, while Wechsler, Isreal, and Balinsky (1941) discovered similar findings for borderline retardates. Needless to say, a severely retarded child would be expected to have a poorer short-term memory than a moderately retarded child, who would similarly be expected to possess a poorer short-term memory than a normal child. The basic question, however, which must be asked is: Do normally intelligent and mentally retarded individuals store the same kinds of information in the same manner and, therefore, can the same test(s) be utilized to evaluate the short-term memory abilities of both groups.

There are many causes of mental retardation, ranging from brain damage to lack of brain development as related to genetic influences. Much of the relevant literature, however, does not distinguish among these various etiologies. When evaluating certain skills, this fact is particularly relevant to genotypically different children whose brain structure and function may differ as a function of their chromosonal structure, and thus manifest different skills when tested due to

their unique brains (Pendleton, 1973; Evans, 1973). It is therefore important to isolate the type of mental retardation to be investigated.

The most common, clinically defined type of mental retardation is mongolism (specifically, Trisomy 21) (Weber, 1970). This particular type of chromosomal anomoly is usually caused by a nondisjunction (an accident, resulting in an extra G chromosome), the result of which produces retardation which generally falls within the moderate range (Ferrell, 1969).

In conjunction with the chromosonal differences of the Down's population has been the recent discovery of varying levels of a metabolic substance known as mucopolysaccharide (MPS) (McDonald, Lozzio, and Lotkin, 1970). When found in excessive concentrations (that is, more than 125 mg. per ml. raw urine) MPS has been known to cause degenerative damage to brain tissue. As expressed earlier, because the etiology of a given subject's mental retardation may have a unique effect on his performance of various tasks, it would seem imperative that studies concerned with the examination and evaluation of specific populations begin controlling not only for genetic etiologies, but for MPS level as well. To do otherwise would be overlooking an important factor which may have a dramatic effect on overall subject performance.

I. THE PROBLEM

Statement of the problem. As indicated earlier, most authorities would concur that deficits in auditory retention can critically impair a child's language and general learning ability. Bateman and Wetherall

(1965) have presented averaged and typical profiles for the retarded which suggest a definite patterning on the I.T.P.A., demonstrating a memory deficit. Yet, to date, there is a relative paucity of research data available to serve as a guideline for selecting appropriate evaluative measures for determining the short-term memory abilities of specific types of mentally retarded individuals. And, while researchers are quick to criticize and discredit the accuracy of those tests which are available to us (namely digit span tests), they have offered us few, if any, alternative measures.

Digit span, alone, may be tested several different ways, varying the rate of presentation, inflection of the examiner's voice, or order of the subject's recall, to name a few. Not only, therefore, is it important to determine which type of test should be utilized for a given population, but it is equally critical to resolve which method of presentation should be employed. Such variables may not provide us with the same results for the same population, or accurate results for all populations.

Purpose of the study. The present study was designed to investigate the auditory storage abilities of moderately retarded mongoloid subjects in an attempt to evaluate different methods for assessment. More specifically, the general purpose of this experiment was threefold:

1. To determine whether the degree of propositionality had an equal effect (if any) on both normally intelligent and moderately retarded subjects.

2. To determine whether the rate of presentation of items had an equal effect (if any) on both normally intelligent and moderately retarded subjects.

3. To determine which test(s) of auditory retention appeared to be the most accurate means for assessment (relating to I.Q. level, mental age, and receptive vocabulary age) of moderately retarded and normally intelligent subjects.

In addition, the possible effects of high and normal levels of MPS on auditory retention abilities were investigated.

II. HYPOTHESES

This study was designed to examine the following null hypotheses:

1. There is no significant difference among five different tests of auditory retention for moderately retarded mongoloid subjects.

2. Presenting items at the rate of one per second and two per second has no significant difference upon the recall abilities of moderately retarded mongoloid subjects on five different tests of auditory retention.

3. There is no significant correlation between short-term memory abilities and mental age scores from the Stanford-Binet Intelligence Scale and Peabody Picture Vocabulary Test for moderately retarded mongoloid subjects.

4. There is no significant correlation among five different tests of short-term memory for moderately retarded mongoloid subjects.

5. There is no significant difference between the auditory storage abilities of moderately retarded mongoloid subjects with a

relatively high level of mucopolysaccharides and those with a normal mucopolysaccharide level.

III. DEFINITION OF TERMS

Auditory retention. Auditory retention is referred to as the ability to store linguistic or non-linguistic auditory stimuli for a matter of moments. It may be measured by three different indices; recall, recognition, and relearning (see page 9 for definitions of these terms).

Down's Syndrome. Down's Syndrome is defined as the most frequent chromosomal disorder and most common clinically defined type of mental retardation (Heber, 1970), usually resulting from an extra G chromosome. While there are three different causes of Down's Syndrome (that is, translocation, nondisjunction, and mosiacism), this particular study is concerned with only one (nondisjunction).

Long-term memory. Long-term memory is defined as the process for which the ability to retain information is maintained over a matter of days, weeks, months, or years.

Memory span. Memory span refers to the maximum number of items which an individual is able to recall in proper order without a single error. Digit span, word span, and commission span are names used to label the memory span for particular types of stimuli.

Moderately mentally retarded. Moderately mentally retarded refers to those individuals whose I.Q.'s from the Stanford-Binet fall within the range of 36 to 51 (American Association of Mental Deficiency, 1973).

Mucopolysaccharides. Mucopolysaccharides are metabolic, biochemical substances composed of three basic sulfates; Chondroitin Sulfate A, Chondroitin Sulfate B, and Heparitin Sulfate. Accumulation of mucopolysaccharides (MPS) is prevented, in normal human beings, by the existence of various enzymes. When these enzymes are found to be deficient, excesses of MPS result. Associated with such excesses (defined as 125 mg. or more of MPS per ml. raw urine) are often physical anomolies and degenerative damage to brain cells (leading to severe mental retardation by school age). Six specific Mucopolysaccharidoses have been identified (McKusick, 1966). These syndromes differ as a result of the specific enzyme(s) which are deficient and are characterized, therefore, by different qualitative aspects of the MPS excess. Deficiencies of either heparitin sulfate sulfatase or N-acetyl-a-glucosaminidase, for example, have been found to cause excesses of heparitin sulfate (the common ingredient of Hurler's, Hunter's, and Sanfilippo Syndrome; all three associated with severe mental retardation).

Oral commissions. Oral commissions are a type of auditory retention test which assess the ability of an individual to remember and carry out a number of different tasks after hearing the directions only once. The separate tasks usually have to be performed in the same order with which they were presented by the examiner. The number of these tasks which a given individual can correctly perform is considered to be his oral commission span.

Propositional stimuli. Propositional stimuli refers to information which provides meaning to a listener. Nonpropositional stimuli,

in contrast, are non-language units which have no rules, associative strengths, predictability, or meaning. They are, therefore, random and unrelated.

Primacy. Primacy is defined as the tendency of an individual to recall the first few items of a sequence more readily than the last items.

Recall. Recall is the ability to reproduce as much of the original material without benefit of external cues. Immediate recall is one procedure utilized for testing auditory retention abilities.

Recency. Recency refers to the tendency of an individual to better recall the last few items presented in a sequence than any other items.

Recognition. Recognition requires the ability to discriminate between several different items. It is one of the methods utilized for testing short and long-term memory abilities. An individual's recognition memory is usually superior to his recall ability.

Rehearsal. Rehearsal is the strategy utilized which enables individuals to maintain information in short-term memory until it can either be recalled or processed into long-term memory. It is simply the constant repetition of items in one's mind. Once rehearsal is terminated, if the information has not entered long-term memory it will be forgotten within a matter of seconds.

Relearning. Relearning may be measured by comparing the original learning span with the length of time needed to relearn the task.

Short-term memory. Short-term memory is defined as ". . . how much a person recalls, recognizes, or reproduces" immediately after

the stimuli has been presented (Belmont and Butterfield, 1969). It is a process which has never left consciousness. Synonyms for short-term memory are "initial memory," "primary memory," "short-term store," and "immediate memory." For the purpose of this study, short-term memory refers specifically to auditorily presented stimuli.

Unrelated words. Unrelated words is a term which describes the characteristics of certain types of stimuli utilized to assess auditory retention abilities. It refers specifically to sequences of common words, varying in length and number, which are grouped and positioned without respect to grammatical rules. There is no association, unless by chance, between one word and the next.

CHAPTER II

REVIEW OF THE LITERATURE

The purpose of this chapter is to review the literature discussing eight major areas: (1) The relationship of short-term memory to language and mental retardation, (2) Theories and limitations of short-term memory, (3) Rate of presentation; its effects on STM, (4) Order of recall in short-term memory, (5) Meaningfulness and expectancy of stimuli, (6) The chemistry of memory, (7) Mucopolysaccharide level and memory, and (8) Down's Syndrome and mental retardation.

I. THE RELATIONSHIP OF SHORT-TERM MEMORY TO LANGUAGE AND MENTAL RETARDATION

According to Carrow (1972, p. 57):

> Memory is an integral part of the language process. . . . Memory . . . records the classes into which similar events may be grouped. And because many events are received in temporal sequence which is essential to their meaning, the memory provides a means for retaining them in order.

There appears to be little doubt that impaired memory has a direct effect on language and general intellectual development. It has been suggested by several authorities (Scott, 1968; Talland, 1968; Ebbinghaus, 1964; Orton, 1937; Underwood, 1964; Barbizet, 1970; Ellis, 1963, 1969; Posner, 1963; Belmont and Butterfield, 1969; Spitz, 1966; Berkson, 1973) that short-term memory deficits may be an underlying cause of some types of mental deficiency. Orton (1937) revealed, in regard to the retardation of children with minimal cerebral dysfunction,

that "It is the recall of sounds in proper temporal sequence which seems to be at fault."

Most memory studies, in support of the above theory, have demonstrated that retarded subjects do extremely poorly on tasks requiring the recall of sequentially presented stimuli. Aten and Davis (1968, p. 244) found that ". . . children with minimal or mild cerebral dysfunction performed more poorly as evidenced in shorter perceptual spans, reduced number of stimuli retained, and less accurate reproduction of sequential information than did a comparison group of normal children." Monsees (1957) and Ingram (1960) discovered that various types of cerebral pathology could cause disturbances in auditory perception. And further, Lowe and Campbell (1965, p. 314) state that "It would appear that the temporal ordering malfunction of the aphasoid child . . . may be a factor contributing to his communication problem." Similarly, Chapouthier (1973, p. 384) states that "The inability to repeat verbal stimuli, including letters and digits, has been recorded in patients with left-hemispheric cerebral lesions . . . as a relatively isolated disability."

While traditional workers in memory (Melton, 1963; Postman, 1964) have argued against dichotomizing memory, there is a growing belief today that not only is memory a two-fold process, but that some mentally deficient individuals may have no deficit in long-term memory (Ellis, 1963, 1966; Belmont, 1966; Berkson, 1973). Posner (1963) explains that recently short-term memory has been examined as a potential basis for the entire question of retention. Berkson (1973, p. 64) contends that "Once information is stored in long-term

memory, it is not forgotten more rapidly by retarded than normal subjects. . . . The difference between normal and many retarded individuals resides in the process of getting information into long-term memory and/or retrieving it."

Short-term memory has been found to follow a similar developmental pattern as general intelligence (Jenson, 1965; Scott, 1968; Hunter, 1962). Jacobs (1887, p. 76) first discovered that "The power of reproducing a number of sounds increases steadily with age." Humpstone (1917) reported a .50 correlation between age and digit span. Hunter (1962, p. 49) presents a detailed developmental description of memory span:

> The relationship between age and learning has been most adequately explored with regard to the memory span for digits auditorily presented. . . . According to the published norms, children have average memory spans of 2, 3, 4, 5, and 6 digits at the years of 2 1/2, 3, 4 1/2, 7, and 10 respectively. Thus, there is a steady but progressively diminishing increase in span with increasing age. This increase continues more and more slowly until the span reaches a steady average value of about seven digits between the middle teens and 30 years. . . . Then somewhat about the age of 30, the span begins to decline slightly. . . . By the middle fifties, the average span has shrunk to six digits; that is, to the level of a ten year old.

Wells (1923 and 1927) first proposed that "memory quotient" could be utilized as a similar concept to I.Q. and Wechsler (1945) developed the first standardized memory scale for clinical use. This test contained seven subtests, each designed to assess a different aspect of auditory and visual retention. Since then, short-term auditory memory tests have become a part of most verbal oriented intelligence tests.

Underwood (1964) contends that immediate recall tests are so accurate in their assessment that they alone can be utilized to

determine the degree of learning of an individual. Barbizet (1970) states that a subject's immediate memory capacity is so stable for certain types of material that it can be considered a "Psychological constant."

II. THEORIES AND LIMITATIONS OF SHORT-TERM MEMORY

Organization Theory. In one of the first reported experiments on short-term memory, Jacobs (1887, p. 75) stated that "It is obvious that there is a limit to the power of reproducing sounds accurately." It was not until 1940, however, that George Katona, in his book Organizing and Memory, first explained that "grouping" was the method utilized to overcome memory limitations. In 1956, Miller proposed his Utilization Hypothesis which held that: (1) the memory span of a normal adult is limited to seven unrelated items, plus or minus two, and (2) the only way in which this limit may be expanded is to recode or reorganize new information into meaningful units. In this manner, the amount of information which each item conveys is increased. Such informationally rich units were referred to as "Chunks." Miller contended that (p. 95) "By organizing the stimulus input simultaneously into several dimensions and successively into a sequence of chunks, we manage to break . . . the information bottleneck." Evidently, there is no limit to the number of units each chunk may contain, or the number of categories that can be formed and recalled (Basden and Higgins, 1972).

Mandler (1967, p. 333) claims that "If organization determines recall, then the categories available to a subject should also determine

the form of his output." Needless to say, if organization determines the extent of recall, then short-term memory could conceivably be impaired by an inability to chunk. This is exactly what Spitz (1966), Routh (1973), and Berkson (1973) maintain. According to Spitz (1966, p. 26):

> It is possible that the differences between subjects is not due to memory but to the manner in which incoming stimuli are organized. . . . It is just possible that many retardates do not divide or group numbers at all. Their memory may be perfectly good but because of an inability to organize material they are overloaded. . . . [Therefore] memory may be a function of processing input . . . [and] there is no way to measure the way in which incoming information is categorized or abstracted.

Berkson (1973) has more recently stated that perhaps retarded individuals have not learned these strategies as well as normal individuals, and therefore are less efficient at storing new information.

The organization approach to memory disorders would appear to suggest that corrective therapeutic techniques should be directed toward teaching retardates to utilize appropriate strategies, beginning at the earliest possible age.

Bottleneck Theory. According to Berkson (1973), while the retarded child may store new information normally, the difficulty lies in his inability to retrieve it. Tulving (1967) investigated this question by presenting subjects with 36 nouns and demanding four different recall trials after various time intervals. The fact that all subjects were able to recall words in later trials which they were unable to recall in earlier ones strongly suggests that retrieval, and not storage, is the problem. Mandler (1967), in light of Tulving's discovery, theorized that while all information may be available, only

some of it may be accessible. Bartz (1968, p. 17) has therefore concluded that "The manner in which information is stored determines the ability to retrieve it." Spitz (1966) has found that retarded subjects have much smaller deficits in recognition memory than recall memory.

Limited Buffer Theory. The limited buffer theory was initially called the Channel Capacity Model by Broadbent (1958). He proposed that each individual possessed a limited short-term store (S-system) which held a small amount of information for a matter of seconds. Once information gained access to this system any one of three things could happen to it: (1) it could be forgotten, (2) it could be processed into long-term memory, or (3) it could be maintained in short-term storage as long as the information continued to be rehearsed. Atkinson and Shiffrin (1968) claim that once the buffer is full (that is, once it has reached its limit in the amount of information which can be held) further or additional items coming in tend to knock out those items already present on a "first in, first out" basis. Therefore, words at the end of the list will be remembered easier than those at the beginning of the list, which may have been knocked out of the system. Zeaman and House (1963) suggest that it is possible that retardates have a reduced buffer size and therefore have a stronger tendency to store only the last items presented.

Stimulus Trace Theory. Although many authorities today attribute the trace theory of memory to Ellis (1963), the concept dates back at least as far as Pavlov (1927) when he contended that a stimulus

trace was the ". . . molar aftereffect following the termination of a brief stimulation." Kohler (1929) proposed a "Fading Trace Theory" to account for the negative time error in psychophysical judgment. Hilgard and Marquis (Ellis, 1963) recognized in 1940 the reverberatory circuit (first described by Lorente de No') as a likely basis for short-term memory. Hebb (1949) proposed the Dual Trace Mechanism which suggested that a brief reverberatory trace follows a sensory event which, therefore, accounts for immediate memory. Hebb suggested that such a trace would produce structural changes in the nervous tissue which would constitute long-term memory. It was not until 1963 (Ellis), however, that the stimulus trace idea was tied into deficits in short-term memory. Ellis proposed at that time that retardates possessed inadequate short-term memory because of an attenuated stimulus trace, both in amplitude and duration. In normals, the amplitude and duration of the trace increases with chronological age.

Attention Hypothesis. Zeaman and House (1963) hold that retardates have a poor probability of observing certain relevant dimensions rather than an inability to learn which cue is correct. And, because retardates can only attend one dimension at a time, other stimuli do not act as cues for them.

III. RATE OF PRESENTATION; ITS EFFECTS ON STM

One aspect of continuing controversy in short-term memory studies involves the rate at which stimuli are presented to the subjects. The overall effect on recall of fast versus slow presentation

rates or short versus long interstimulus intervals still appears to remain in question. Reducing the rate may, by forcing the subject to hold on to the information in short-term storage for a longer period of time, ". . . allow more time for decay and therefore result in lower recall" (Aaronson, 1967, p. 131). Proponents of this theory would, therefore, expect to find improved recall with increases in presentation rate. Studies with such findings include: Conrad and Hille (1958), Fraser (1958), Headrick and Ellis (1964), and Posner (1964).

Reducing the presentation rate may, on the other hand, allow the subject more time for perception, association, recording, rehearsal and other strategies which might facilitate recall (Posner, 1964; Aaronson, 1967; Laughery and Pinkus, 1968). Experiments demonstrating improvement with reduced presentation rates include: McCarthy and Kirk (1962), Pollack, Johnson, and Knaff (1959), Melton, Sameroff, and Schubet (1963), Norman (1966), Pollack and Johnson (1963), Posner (1963), Murdock (1960), Aaronson (1966), Mackworth (1962), Yntema, Wozencraft, and Klem (1964), and Jahnke (1968).

Aaronson and Sternberg (1964) found that the rate of presentation often determined the type of strategy utilized by subjects. Subjects receiving slow presentation rates, for example, attempted to identify the items during the presentation, while those who received fast rates delayed such identification until all the items had been presented. As a result, more incorrect digits were repeated by subjects utilizing an "immediate strategy" while more order errors were found among those employing a "delayed strategy."

There are, of course, studies which have found no significant differences in recall from varying the presentation rate. Among these are: Calhoon (1935), Fraisse (1945), Pollack (1952), and Ellis (1970).

Aaronson (1967) contends that experiments investigating rate often combine two separate variables; duration of the stimulus and duration of the interval between stimuli. According to Aaronson, the duration of the stimulus may determine how much information enters the buffer, while the duration of the interstimulus interval may effect the time available to identify or organize the material. He contends that there may be an optimal ratio of the stimulus duration to the interstimulus interval for each individual. As previously indicated, most studies have not treated these variables as separate conditions. Normally, when the speaker increases his vocalizations, the intervals and word durations are simultaneously decreased. Aaronson concludes that ". . . confounding the duration and presentation rate may, in part, account for the conflicting data on presentation rate" (Aaronson, 1967, p. 133).

Bergstrom (1907) found a uniform decline in recall errors with increasing time intervals from 0.5 to 0.2 seconds. He concluded that the percentage of correct responses (for words, in this case) varies as the log of the interstimulus interval. Hutton (1954), in another of the few studies where both the stimulus and interstimulus durations were controlled found that when the stimulus duration was held constant, recall was best with longer interstimulus durations.

A recent study of particular interest was conducted by Ellis (1970). Improved recall was reported for normal subjects when the interstimulus interval was increased. No such improvement, however, was observed for retardates. Ellis attributed this lack of change to the possibility that retardates do not rehearse, and therefore do not benefit from the extra time made available for such strategies.

Of course there are other factors which may vary the effects of presentation rate. Among these is the propositionality and/or expectancy of the material presented. Titchner's Law of Prior Entry (1908) states that "The stimulus for which we are predisposed requires less time than a like stimulus, for which we are unprepared, to produce its full conscious effect." This facet of short-term memory will be discussed later.

IV. ORDER OF RECALL IN SHORT-TERM MEMORY

According to Waugh (1965, p. 89) "The span of immediate memory must be limited in a large part by our inability to rehearse, and hence retain, the early items in a sequence while attempting to store the latter ones." Waugh suggests that our limited memory span is the result of an inability to ". . . think about two things at the same time."

Order of recall has been a facet of short-term memory studies that has demonstrated some of the most significant differences between retardates and normals. Galton (1887) was probably the first investigator to recognize a recency effect when he found that the last word in a sequence was the easiest to repeat, and after this the first.

Aaronson (1967) reported that if the list of items is within our short-term memory span, we almost always recall the items in their original order. Once these lists exceed our memory span, however, and we become unable to recall all of the items, we usually repeat the most recent item in the series; hence the term "recency." This phenomenon remains, according to Murdock (1962) and Waugh (1965), irrespective of the number of items in a series, but only if the series may be recalled immediately. Warrington and Weiskrantz (1973, p. 368) similarly maintain that "The high probability of recall of the last four to five items on the list is no longer present if recall is delayed 20 or 30 seconds. . . ." This loss of recency by a time delay is supported by Anders (1971) and can be seen in Figure 1.

Siegel and Allik (1973), in an investigation involving groups of kindergarten children, second graders, fifth graders, and adults, found that the initial and middle portion in serial position was increased with increasing developmental age. Since, according to Ellis (1970), rehearsal strategies are responsible for facilitating primacy (that is, the ability to better retain the early items of a list), Siegel and Allik contend that their findings are supportive of Bernbach's (1967) "Rehearsal Hypothesis" which states that "The absence of a primacy effect is due to a failure of young subjects to rehearse."

Berkson (1973) and Ellis (1970) describe similar findings with retarded subjects. While recency effects both normals and retarded subjects alike, evidently normals are more able to overcome primacy deficits by rehearsal and grouping strategies. Retardates, conversely,

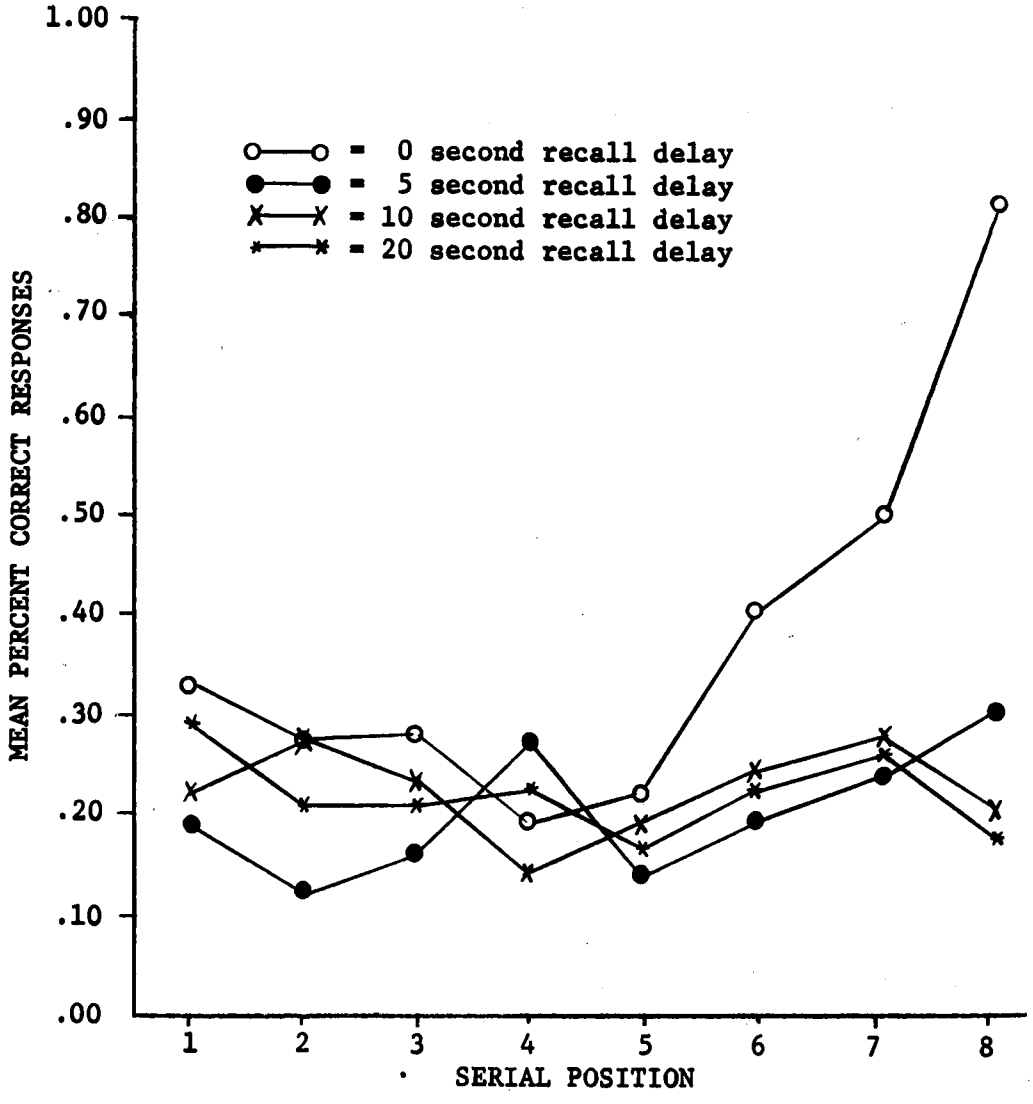

Figure 1. Mean percent correct responses for retarded subjects as a function of serial position and length of recall delay.

Source: Terry R. Anders, "Short-Term Memory for Serially Presented Supraspan Information in Nonretarded and Mentally Retarded Individuals," American Journal of Mental Deficiency. 75:571-578, 1971.

probably do not rehearse and for this reason are unable to improve recall for any of the early items in the list. Figure 2 illustrates this concept.

Even with rehearsal strategies, however, Conrad (1950) reported that over 50 percent of all recall errors for eight digit sequences were mistakes in the order in which the items were recalled. Aaronson (1967) and Deese and Halse (1958) have indicated that any time subjects are required to recall items in an order which is different from the original presentation, more errors result. Kay and Poulton (1951), for example, found that when subjects were directed to repeat the last half of a list first, their recall abilities dropped. Aten and Davis (1968, p. 242) report that "The digits backwards test was statistically and clinically discriminating between groups" (minimal cerebral dysfunction subjects and normals). This finding was anticipated by Wechsler (1949) and Rey (1958). Evidently, the process of retaining the elements, transposing them, and producing a response that is different from the original stimulus sequence requires a cognitive capacity that is beyond the average capabilities of individuals with brain damage.

V. MEANINGFULNESS AND EXPECTANCY OF STIMULI

One of the critical aspects of short-term memory experiments is the degree of propositionality of the stimuli. Ebbinghaus (1885), in the first published experimental study on human memory, expressed his desire to avoid utilizing regular German words because they had too many associations with other words. Such associations, he felt,

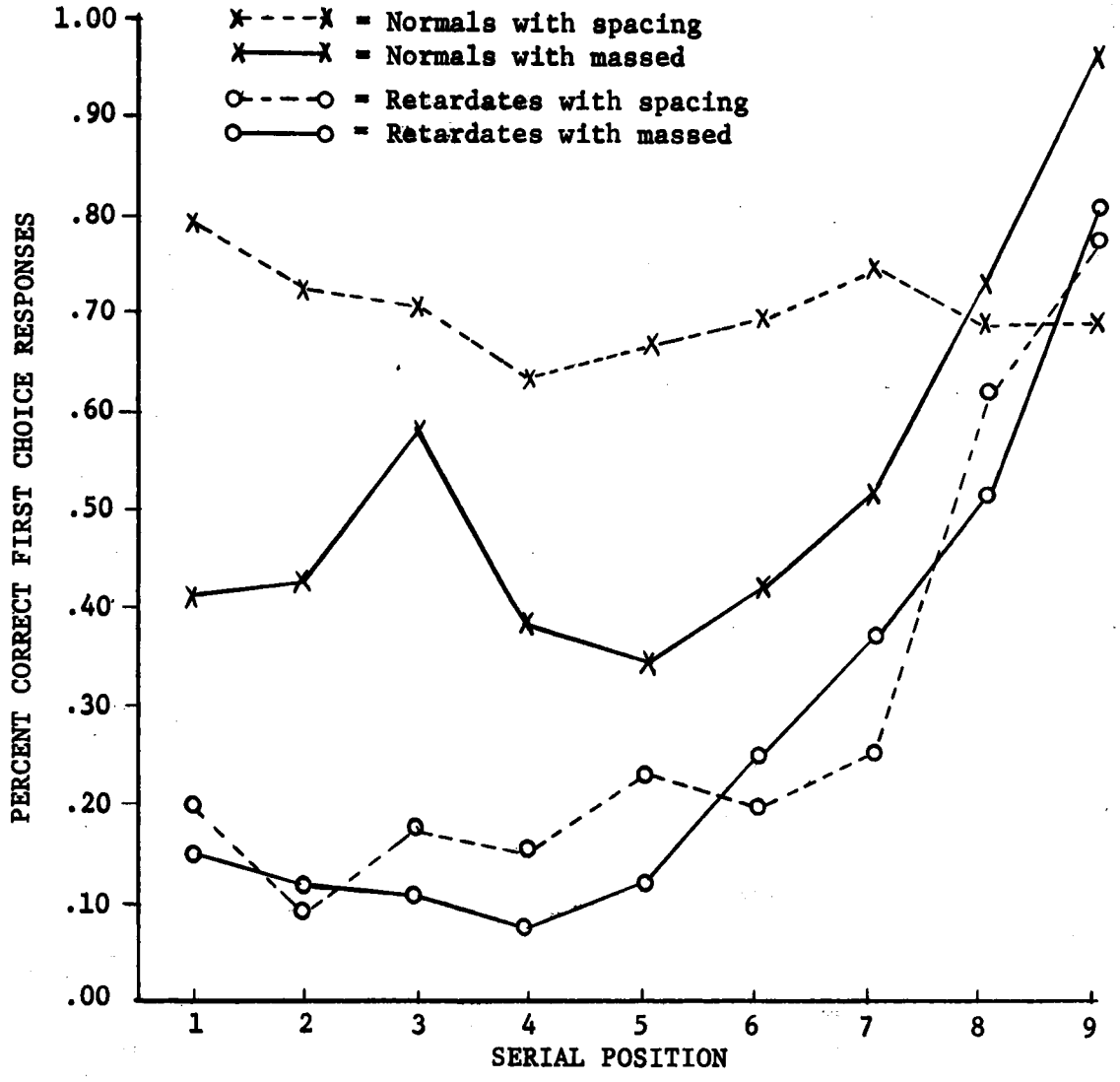

Figure 2. Effect of interstimulus duration variations on serial position of recall.

Source: Norman R. Ellis, "Memory Processes in Retardates and Normals," International Review of Research in Mental Retardation, 4:1-32, 1970.

would involve previously learned experiences and thus contaminate his experiment. For these reasons, Ebbinghaus utilized nonsense syllables. He believed that these were devoid of meaning and therefore equally difficult. They could also be presented in any order and have no significant effect on recall ability. Studies since then (Glaze, 1928; Archer, 1960; Noble, 1952; Mandler, 1955) have demonstrated that nonsense syllables are not devoid of meaning, do indeed have various associations, and therefore are not uniform in difficulty.

Most authorities appear to be in agreement that highly meaningful and/or expected items are easier to store briefly (or process into long-term memory) than unfamiliar, unrelated, and unexpected items. Miller and Selfridge (1953, p. 179) explain that "The experimental literature contains considerable evidence to support the reasonable belief that nonsense is harder to remember than sense." Jacobs (1887) recognized this and chose, therefore, to utilize letters and digits rather than the nonsense syllables Ebbinghaus had employed. Jacobs contended that syllables were new to the listener and, thus, had to be learned.

The earliest reported attempt to calibrate the meaningfulness of stimuli was conducted by Glaze (1928). Consonant-vowel-consonant syllables (CVC's) were presented to listeners who were asked to indicate which ones had associations. The percentage of listeners reporting associations for a particular nonsense syllable was used to predict the ease with which it may be combined with others. Archer (1960) updated Glaze's experiment by asking listeners more detailed questions about each CVC syllable. Such questions attempted to

discover whether or not a particular nonsense syllable resembled a word or reminded the listeners of a real word. Other variables such as morphology have been utilized as means for predicting the familiarity, and possible ease of recall, of certain syllables.

The degree of meaningfulness of regular words was investigated by Thorndike and Lorge (1944). Their study was based upon the assumption that the frequency of occurance of various words, found in different kinds of printed sources, was an adequate predictor of the rate of verbal learning. Underwood and Schulz (1960) found that familiar material was learned more rapidly than unfamiliar, nonmeaningful material. Treisman (1965) demonstrated that more predictable and redundant passages could be organized into larger units and thus reduce the load on memory and facilitate recall. Similarly, Spence (1969) found that the more predictable the test material, the less attention the listener had to pay to it, and the more time he could spend organizing it. Spence made a special point of saying, however, that a decrease in meaningfulness could not be completely offset by an increase in attention. Miller and Selfridge (1953) state that meaningful material is easier to store because of its familiarity to the listener, but in addition hold that familiar nonsense is also easily retained.

In normal language sequences, preceding words determine the listener's possible choices for the following word. When unrelated words are utilized, preceding words have little effect (Deese and Halse, 1958). Studies using unrelated words have found that, independent of associative strengths and interword relationships,

certain types of words are easier to recall than others. Semmel and Herzog (1966) discovered that nouns and adjectives were more easily recalled by nine- and thirteen-year-old EMR children than verbs and adverbs. They speculated that the reason was because nouns and adjectives represent concrete concepts (that is, they symbolize physical entities) while verbs and adverbs tend to be more abstract and characterize relationships between concepts in the physical environment.

Just as the meaningfulness of various words and syllables can be calibrated, so can the approximation to normal English sequences be determined. A series of unrelated words, to illustrate, represents a zero-order approximation to English (Deese and Hulse, 1958). A first-order approximation occurs when the words in the sequence are chosen by frequency of occurence. To determine a second-order approximation, a word is presented to a subject, who is asked to use it in a sentence. The word following the given word is then presented to another subject who develops the third word. An example of a second-order approximation would be: "was he went to the newspaper is and deep and" (Deese and Hulse, 1958, p. 261). Each word, then, is statistically dependent upon the word which precedes it. For higher-order approximations, a number of words are presented to a listener to construct a sentence with. The first word of the series is then dropped and replaced by the new word supplied by the listener. If the original sequence given to the listener contains five words, it results in a sixth-order approximation. Miller and Selfridge (1950) investigated the recall abilities of different orders of approximation. They found a gradual increase in recall ability until the fifth-order

of approximation, at which time correct recall scores plateaued at approximately 98 percent (for a ten word sequence).

Epstein (1961) discovered that sequences of nonsense syllables were easiest to learn when they were organized in orderly English syntax. This would appear to suggest that possibly the organization of words within a sequence is as important as the meaning of the words. If, indeed, certain types of arrangements of material are more easily stored than others, one would expect to find varying memory span norms for each type of stimuli. Jacobs found this to be true as far back as 1887 and proposed that if an individual could repeat, on the average, 6.1 nonsense syllables, he would most likely be able to repeat as many as 7.3 letters and 9.3 numbers. Further recent evidence (Miller, 1956; Tulving and Patkau, 1962) holds that while a normal adult can retain seven digits, the span for monosyllabic words is only about five, while Hunter (1962) found that the average spans for university students were as follows: Digits = 8 1/2; Common Nouns = 6; and Nonsense Syllables = 3.

VI. THE CHEMISTRY OF MEMORY

The chemical or molecular basis for memory has been investigated by several authorities. Gaito and Zavala (1964) have suggested that changes in memory occur at synapses, since behavior is a synapse activity. The levels of acetylocholine (ACh) and acetycholinesterase in the brain, as a function of the experiences of the organism, have been examined because these chemicals are critical to synaptic transmission. Deutch (1973) believes that, while synaptic changes do occur

as a result of stimulation, there is no evidence that these changes are those utilized in the nervous system for information storage. Overton (1959) contends that learning is facilitated by a decrease in calcium ion concentration at the synapse, and retarded by an increase.

Since one-half of the dry weight of the brain is protein (Booth, 1973), it might be logical to assume that the memory process involves some form of protein interaction or synthesis. DNA and RNA have been suggested as possible memory ingredients (Hyden and Egyhazy, 1964; Hyden and Lange, 1965). Nucleic acids are actually thousands of proteins bound together by amino acids. RNA in particular determines and controls the specific form of proteins that are synthesized within each neural cell (Gurwitz, 1969). Gurwitz holds that if RNA is the memory mechanism, then it should be possible to facilitate or inhibit memory by means of drugs which interfere with RNA synapsis. Three main drugs have been utilized concerning this theory; 8-azaguanine, actinomycin-D, and TCAP (1,1,3-tricyano-2-amino-propene). The first two have been utilized to interfere with RNA synthesis, while the latter has been used as an RNA inhancing agent.

Cameron (1958) attempted to enhance the memory of the aged by administering a mixture of DNA and RNA in a saline solution. A battery of memory tests was then presented, with best results found in patients with severe memory deficits. Studies with rats (Coroson and Enesco, 1966; Cook, Davidson, Green, and Fellows, 1963; Wagner, Carder, and Beatty, 1966) have found that those who have been injected with varying amounts of RNA demonstrate fewer errors in maze learning, faster avoidance reactions, and so forth.

Several studies have been conducted concerning the transfer of RNA and memory (learning experiences) from one organism to another. Aelman, Kabat, Jacobson, and McConnell (1963) produced the first of such experiments. Trained worms were ground up and RNA was extracted. Untrained worms were then injected with the extract and given light-shock conditioning trials. Statistically significant differences were found between those worms injected with RNA taken from trained worms and those injected with RNA taken from untrained worms. Jacobson, Babich, Bubash, and Goren (1966) conducted further studies which tend to support the notion that acquired behaviors can be transferred by means of RNA injections.

VII. MUCOPOLYSACCHARIDE LEVEL AND MEMORY

The amount of mucopolysaccharide found in the urine of normal individuals is usually around 3 to 15mg. per ml. for a 24 hour period (Rich, 1957). MPS is essentially composed of three sulfates; chondroitin sulfate A (which comprises approximately 80 percent of the MPS), chondroitin sulfate B, and heparitin sulfate. Six specific syndromes have been biochemically, clinically, and genetically defined which are believed to be the result of excessive amounts of MPS. Common clinical descriptions among these six disorders (termed mucopolysaccharidoses) are dwarfism and stiffness of the joints. Three of the MPS syndromes (that is, Hurler Syndrome, Hunter Syndrome, and Sanfilippo Syndrome) are characterized by normal development initially, with rapid deterioration of the mental processes. Severe mental retardation is usually apparent by school age. The remaining three

syndromes, however (Morquio Syndrome, Scheie Syndrome, and Maroteaux-Lamy Syndrome), have reported mild mental retardation or normal intelligence. McKusick (1966) indicates that biochemical analysis has shown that heparitin sulfate is absent in the three MPS syndromes associated with normal or near normal intelligence. In contrast, excesses of heparitin sulfate have been found to be common among the three MPS syndromes reporting degenerative damage to brain tissues. McKusick concludes that it may be the high level of heparitin sulfate that is critical rather than just a general increase in MPS concentration. Terry and Linker (1964), however, state that their findings do not agree with McKusick.

The relationship of MPS level to memory is difficult to assess because the basic biochemical processes and ingredients of memory still remains in question. If nucleic acids (more specifically, RNA) and proteins are the critical elements, then MPS may have a direct relationship with memory. According to McKusick (1966, p. 388):

> Normally mucopolysaccharides are tightly bound to protein. . . . Possibly because of the change in the amino acid sequence, binding is less effective. The mechanism for normal control on synthesis of mucopolysaccharides may not be operative, with the result that excessive mucopolysaccharides continue to be produced.

VIII. DOWN'S SYNDROME AND MENTAL RETARDATION

Down's Syndrome was first described in 1866 by Langdon Down, who utilized the term "mongolism" to indicate those individuals who exhibited a delay in physical and mental development, and whose slanting eyes and flat nose gave them an appearance resembling members of the Mongolian race (Kock and Dobson, 1971).

A normal individual has 46 chromosomes (23 pairs) plus two sex determining chromosomes (either XX for a male or XY for a female). In the Down's population, however, an extra chromosome, first discovered by Lejeune, Gautier, and Turpin in 1959, is observed in the G group. Despite the fact that Down's Syndrome is frequently referred to as Trisomy 21, it is still uncertain as to whether the extra chromosome is actually number 21 or 22 (Kock and Dobson, 1971). Lilienfield (1969) also points out that not all mongoloids are the result of the trisomy. Approximately two-to-three percent of Down's infants are the result of a translocated chromosome which could have been carried by normal parents for several generations. Another 2 percent are mosiac mongoloids, which can be the result of either a nondisjunction or can arise from an abnormal zygote with a trisomy due to the loss of the extra chromosome during mitosis. In general, about 8 percent of mongoloids born are the result of inheritance, with the remaining 92 percent being caused by an accident of nature.

Language and intelligence. The I.Q.'s of most individuals with Down's Syndrome appear to vary between 25 and 50 (Ferrell, 1969) and it is exceptional to find a mongoloid possessing an I.Q. greater than 60 or 65 (Tredgold, 1972). Strazzulla (1971, p. 229) found that mongoloids possessing I.Q.'s between 40 and 70 ". . . begin using words at an average age of 33.4 months and utilize phrases at a mean age of 48 months." Sentences were not observed until 60.8 months. In a study conducted by Engler (1947) only 49 percent of institutionalized Down's Syndrome children had begun to speak by the

age of three years; 60 percent by the age of four years; and 81 percent by the age of five years.

The uniqueness in the performance abilities of mongoloids, as a function of their specific etiology (and therefore genotypically unique brain structure) has been recently investigated by Evans (1973) and Pendleton (1973). The results from these studies indicate that mongoloids possess significantly poorer auditory decoding and visual discrimination skills than do retardates with comparable mental age and I.Q. levels but different etiologies. This tends to support the findings of Bilovsky and Share (1965), who observed that mongoloids differed from other retarded subjects in their ability to understand pictures. In general, however, there is little information reported in the literature in regard to the possible differences of retardates as a function of their specific genetic etiologies.

MPS level in Down's Syndrome. High levels of mucopolysaccharides have recently been observed in some mongoloids. Research conducted by MacDonald, Lozzio, and Lotkin (1970) has indicated that approximately 50 percent of those Down's subjects screened possess high levels of MPS (that is, greater than 125 mg./ml. raw urine). Evans (1973) and Pendleton (1973) found no significant differences, however, in the oral and auditory skills of mongoloids with high and normal MPS levels.

Incidence and risk. Currently, there are 65,000 individuals living in the United States who have been diagnosed as having Down's Syndrome. Although the incidence figures may vary from authority to authority, it is fairly well established that approximately 1 in 700

live births within the general population will be a mongoloid child (Koch and Dobson, 1971; Tredgold, 1972). It has been predicted that in over four million newborns each year in the United States, more than eight thousand infants will have Down's Syndrome (Reed, 1963). Today, an estimated 10 percent of all institutionalized mentally retarded patients have been diagnosed as possessing Down's Syndrome (Ferrell, 1969; Koch and Dobson, 1971). Much of the incidence of mongolism has been related to maternal age at conception. Motulsky (1964) has indicated that, while the risk per pregnancy of a mother 29 years of age or less is only 1 in 3000, the risk of a 40-year-old mother giving birth to a mongoloid is 1 in 70. This risk increases even further to 1 in 40 births if the mother is between the ages of 45 and 49.

CHAPTER III

METHODS AND PROCEDURES

The present study was designed to evaluate the accuracy of various tests for determining the auditory retention abilities of moderately retarded mongoloid subjects in comparison with the norms derived for normally intelligent subjects. The investigation was conducted at the Birth Defects Evaluation Center at The University of Tennessee Memorial Research Center and Hospital. This chapter contains a discussion of the subjects used in the study, the criteria for their selection, pretesting information, procedures for testing, and reliability measures.

I. SUBJECTS

The subjects chosen for this study were patients of the Birth Defects Evaluation Center at The University of Tennessee Research Center and Hospital. Each subject was chosen to meet the following criteria:

1. Be white
2. Be between the ages of 5-0 and 12-6
3. Have normal hearing acuity (25 dB ANSI or better) as determined by a certified audiologist with experience in pediatric audiometry.
4. Exhibit no significant oppositional or negative behavior which might interfere with testing and evaluative procedures.

5. Have no history of brain injury or other disabilities and/or illnesses which could inhibit language development (as determined by parent interviews and medical records).

6. Have an I.Q. between 36 and 51 on the Stanford-Binet Intelligence Scale, placing him within the moderate range of mental retardation.

7. Have been genetically diagnosed as having Trisomy 21 Down's Syndrome.

II. PROCEDURES

Obtaining the preliminary information. Information relative to the criteria mentioned was obtained prior to testing by the examiner. All those children satisfying the above criteria were considered as potential subjects for this study.

Pretesting. A certified psychological examiner administered the Stanford-Binet Intelligence Scale to all potential subjects in an effort to determine their acceptability for this experiment. Only those whose I.Q. scores were within the moderately retarded range (as defined above) were considered for further testing and subject grouping.

Subject grouping. The moderately retarded mongoloid subjects chosen for this study were arranged into two separate groups, depending upon their mucopolysaccharide level. Those who possessed high levels (that is, 125 mg. or higher MPS/ml. raw urine) comprised Group I, while the remaining normal MPS subjects (less than 100mg/ml) represented

Group II. Tables I through IV contain summaries of subject chronological age, I.Q., mental age, and MPS level as well as group means and standard deviations.

III. TEST PROCEDURES

Each subject individually received a battery of tests, during one testing session, to determine his auditory storage capabilities. The directions to the subject, scoring procedures, and items to be presented for each test were identical to those found in the manuals of the standardized tests from which they were abstracted. The appendices contain summaries of the above information along "revised directions" which were utilized when subjects could not perform appropriately on the basis of standard directions alone. The order of test presentation was randomized for each subject to prevent subject fatigue from effecting results.

The specific tests which were utilized differed with respect to their propositionality and thus fell within three major categories; digits, unrelated words, and oral commissions. Table V contains a summary of these tests. Each test was administered twice, differing the second time in presentation rate only. Two test conditions were therefore created; Condition I consisted of presenting the items at the rate of one per second (or with one second intervals between items, in the case of oral commissions), while Condition II consisted of presenting the items at the rate of two per second (or with no time interval between commissions).

TABLE I

SUMMARY OF CHRONOLOGICAL AGES, MENTAL AGES, I.Q.'S, AND MPS LEVELS OF ALL SUBJECTS WITHIN THEIR RESPECTIVE GROUPS

Group I High MPS Levels							Group II Normal MPS Levels						
		MPS	S-B		PPVT			MPS	S-B		PPVT	
Initials	C.A.	Level	IQ	MA	IQ	MA	Initials	C.A.	Level	IQ	MA	IQ	MA
R. P.	8-2	200mg	45	3-11	26	2-8	K. J. M.	12-5	12mg	34	3-4	28	3-4
L. B.	10-8	125mg	42	4-2	50	4-8	L. B.	11-11	62mg	57	6-4	61	6-6
J. L.	10-8	125mg	52	5-5	65	6-8	M. A.	8-0	60mg	32	2-10	8	2-2
J. E. B.	10-8	125mg	55	5-9	54	5-2	D. D.	7-9	70mg	37	3-2	26	2-8
S. N.	8-3	125mg	34	2-10	21	2-6	R. P.	7-1	75mg	39	3-1	14	2-3
D. H.	5-9	125mg	55	3-5	49	3-0	T. S.	6-1	75mg	54	3-5	30	2-5
							R. C.	5-7	24mg	39	2-7	40	2-8

TABLE II

A COMPARISON OF CHRONOLOGICAL AGES BETWEEN GROUPS OF MONGOLOID SUBJECTS WITH HIGH AND NORMAL MUCOPOLYSACCHARIDE LEVELS: MEANS, MEDIANS, AND STANDARD DEVIATIONS

Subject Group	Chronological Ages		
	Mean	Median	Standard Deviation
High MPS Level	9-0	9-6	2-0
Normal MPS Level	9-5	7-9	2-9

TABLE III

A COMPARISON OF I.Q.'S BETWEEN GROUPS OF MONGOLOID SUBJECTS WITH HIGH AND NORMAL MUCOPOLYSACCHARIDE LEVELS: MEANS, MEDIANS, AND STANDARD DEVIATIONS

Subject Group	Stanford-Binet I.Q.			Peabody I.Q.		
	Mean	Median	Standard Deviation	Mean	Median	Standard Deviation
High MPS Level	47	49	8	44	50	17
Normal MPS Level	42	39	10	30	26	17

TABLE IV

A COMPARISON OF MENTAL AGES BETWEEN GROUPS OF MONGOLOID SUBJECTS WITH HIGH AND NORMAL MUCOPOLYSACCHARIDE LEVELS: MEANS, MEDIANS, AND STANDARD DEVIATIONS

Subject Group	Stanford-Binet M.A.			Peabody M.A.		
	Mean	Median	Standard Deviation	Mean	Median	Standard Deviation
High MPS Level	4-3	4-1	1-2	4-1	3-10	1-8
Normal MPS Level	3-6	3-2	1-3	3-2	2-8	1-10

TABLE V

SUMMARY TABLE OF AUDITORY RETENTION TESTS UTILIZED AND THE STANDARDIZED TESTS FROM WHICH THEY WERE ABSTRACTED

Test No.	Type	Direction	Rate	Source	Propositionality
1	Digits	Forward & Backwards	1/sec.	W.I.S.C.	Nonpropositional
2	Digits	Forward & Backwards	1/sec.	S-B	
3	Digits	Forward	2/sec.	I.T.P.A.	
4	Words	Forward	1/sec.	Detroit	
5	Commissions	Forward	Spaced	Detroit	Propositional

All raw data collected from each test was converted into mental age equivalents for the purpose of statistical analysis. Tables for transposing such data into mental ages can be found in the Appendix along with corresponding test items.

IV. EXAMINER RELIABILITY

To determine examiner and subject reliability, five randomly selected subjects were retested after a period of at least one week. A reliability coefficient of 88.5 was obtained by the following formula:

$$\text{percent agreement} = \frac{\text{sum of agreements}}{\text{sum of responses}} \times 100$$

CHAPTER IV

RESULTS AND DISCUSSION

This study was designed to investigate the auditory storage abilities of moderately retarded mongoloid subjects. Thirteen subjects, divided into two groups on the basis of mucopolysaccharide level, were presented a battery of five tests of short-term memory. Each test was presented twice, differing the second time in presentation rate only. Statistical analysis was conducted, with .05 alpha level selected as a basis for rejection or non-rejection of each hypothesis.

I. RESULTS

Hypothesis one: There is no significant difference among five different tests of auditory retention for moderately retarded mongoloid subjects. Because only two subjects were able to attain the minimum mental age score on the W.I.S.C. digit span test, the test was not included as a part of the statistical testing. The two factor analysis of variance (factors being groups and tests, with repeated measures on tests) (Winer, 1962, p. 298) revealed that differences between the remaining four short-term memory tests exceeded the .001 level of significance ($F = 28.55$, $df = 3/33$). A Duncan's Multiple-Range Test (Bruning and Kintz, 1968) indicated that only the oral commissions test from the Detroit test battery was significantly different. The mental age scores obtained from the Stanford-Binet and I.T.P.A. digit span tests and the Detroit unrelated words test did

not differ among themselves. This data can be viewed in Table VI. Hypothesis one is rejected.

Hypothesis two: Presenting items at the rate of one per second and two per second has no significant difference upon the recall abilities of moderately retarded mongoloid subjects on five different tests of auditory retention. The mean mental age equivalents, F scores, and significance levels, as determined by the two-factor analysis of variance, are displayed in Table VII. As can be seen from this table, the rate of presentation was not found to be significant ($F = 3.652$, $df = 1/11$). There were similarly no significant interactions. Both groups of subjects scored higher during the two-item per second presentation rate. This can be seen in Figure 3. Null hypothesis two, therefore, is not rejected.

Hypothesis three: There is no significant correlation between short-term memory abilities and mental age scores from the Stanford-Binet Intelligence Scale and Peabody Picture Vocabulary Test for moderately retarded mongoloid subjects. Table VIII summarizes Pearson Product correlations (Bruning and Kintz, 1968, p. 152) for mental age equivalents from the four short-term memory tests. As can be seen from this table, all short-term memory tests correlated highly with I.Q. and mental age scores from the Peabody and Stanford-Binet except the unrelated words test from the Detroit Tests of Learning Aptitude. While the oral commissions test correlated with Stanford-Binet and Peabody mental age scores for both presentation rates, a significant correlation with I.Q. was found only when this test was presented at the standard (spaced) rate.

TABLE VI

THE DUNCAN'S MULTIPLE-RANGE ANALYSIS OF DIFFERENCES OF MENTAL AGE EQUIVALENTS WITHIN THE FOUR TESTS OF AUDITORY RETENTION

Test	Mean Mental Age	Significance*
Detroit Unrelated Words	21.69	+
I.T.P.A. Digit Span	29.73	+ +
Stanford-Binet Digit Span	37.15	+
Detroit Oral Commissions	73.62	

*A line connecting mean scores indicates no significant difference (.05 level of significance) between those means.

TABLE VII

MEAN MENTAL AGE SCORES, F SCORES, AND SIGNIFICANCE LEVELS AS A FUNCTION OF PRESENTATION RATE: ONE ITEM PER SECOND VERSUS TWO ITEMS PER SECOND

	Presentation Rate			
	One Item Per Second	Two Items Per Second	F Score	Significance Level*
Mean Mental Age Score in Months	37.42	43.67	3.652	.0798

*F larger than 4.84 (df = 1, 11) required for significance at the .05 level of significance.

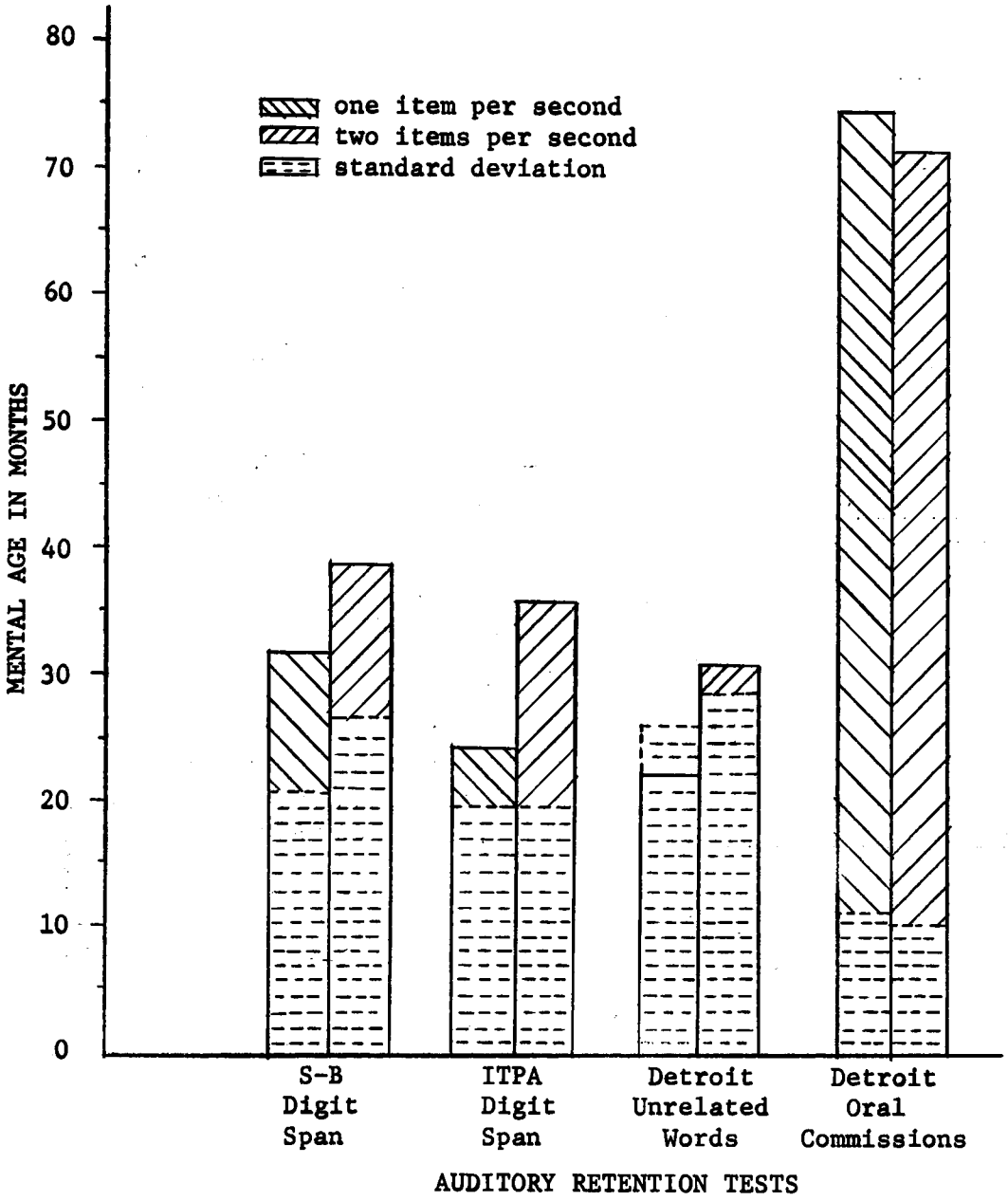

Figure 3. A comparison of four short-term auditory retention tests as a function of presentation rate (high and normal MPS subjects pooled).

TABLE VIII

PEARSON-PRODUCT MOMENT CORRELATION SCORES FOR MENTAL AGE EQUIVALENTS

	Stanford-Binet I.Q.	Stanford-Binet Mental Age	Peabody I.Q.	Peabody Mental Age
Stanford-Binet Digits; 1 per sec.*	.570**	.693**	.626**	.737**
Stanford-Binet Digits; 2 per sec.	.412	.546	.582**	.701**
I.T.P.A. Digits; 1 per second	.691**	.748**	.731**	.781**
I.T.P.A. Digits; 2 per second*	.534	.678**	.696**	.779**
Oral Commissions: Spaced*	.563**	.898**	.742**	.923**
Oral Commissions; Massed	.130	.651**	.300	.619**
Unrelated Words: 1 per second*	.382	.200	.081	.021
Unrelated Words; 2 per second	.430	.445	.380	.445

*Standard method of presentation.

**Significant beyond the .05 level of significance.

Table IX illustrates the relationship among digit span, word span, and oral commission span length with respect to a subject's I.Q. and mental age score. The length of a subject's digit span, regardless of presentation rate, correlated with mental age and I.Q. scores beyond the .05 level of significance.

In general, the various correlations of different short-term memory tests with intelligence quotients and mental age scores indicate that certain relationships between auditory retention skills and intellectual and language development do exist for this subject sample. Hypothesis three is rejected.

Hypothesis four: There is no significant correlation among the five tests of short-term memory for moderately retarded mongoloid subjects. Table X displays correlation coefficients for the four tests of auditory retention. As can be seen from this table, all tests correlated highly with their cognate presentation rate. The Stanford-Binet and I.T.P.A. digit span tests correlated with each other beyond the .05 level ($r = .756$). The oral commissions test (spaced presentation rate only) also correlated with both digit span tests beyond the .05 level. However, no significant correlations were found between unrelated words (one item per second) and any other short-term memory test. The oral commissions and unrelated words tests did not correlate with each other significantly for either presentation rate.

It can be seen, then, that while not all tests of auditory memory achieved significant relationships, such correlations in fact did occur. For this reason, hypothesis four is rejected.

TABLE IX

PEARSON-PRODUCT MOMENT CORRELATION SCORES FOR LENGTH OF MEMORY SPAN

	Stanford-Binet I.Q.	Stanford-Binet Mental Age	Peabody I.Q.	Peabody Mental Age
Digit Span; 1 item per second	.590*	.711*	.588*	.699*
Digit Span; 2 items per second	.561*	.689*	.754*	.830*
Word Span; 1 item per second	.605*	.625*	.512	.578*
Word Span; 2 items per second	.280	.395	.377	.481
Commission Span; Spaced	.649*	.795*	.656*	.770*
Commission Span; Massed	.215	.710*	.512	.751*

*Significant beyond the .05 level of significance.

TABLE X

PEARSON-PRODUCT MOMENT CORRELATION SCORES SHOWING THE RELATIONSHIP AMONG AUDITORY RETENTION TESTS

	Stanford-Binet Digits 2/Sec.	I.T.P.A. Digits 1/Sec.	I.T.P.A. Digits 2/Sec.	Oral Commissions Spaced	Oral Commissions Massed	Unrelated Words 1/Sec.	Unrelated Words 2/Sec.
Stanford-Binet Digits, 1/sec.	.824*	.841*	.756*	.803*	.580*	.188	.748*
Stanford-Binet Digits, 2/sec.		.691*	.859*	.718*	.471	-.059	.712*
I.T.P.A. Digits, 1/sec.			.831*	.766*	.493	.133	.525
I.T.P.A. Digits, 2/sec.				.745*	.509	.007	.663*
Oral Commissions Spaced					.750*	.084	.524
Oral Commissions Massed						-.095	.324
Unrelated Words 1/sec.							.562*
Unrelated Words 2/sec.							

*Significant at the .05 level of significance.

Hypothesis five: There is no significant difference between the auditory storage abilities of moderately retarded mongoloid subjects with a relatively high level of mucopolysaccharides and those with a normal mucopolysaccharide level. Table XI displays the mean scores, F scores, and significance levels for Groups I (high MPS subjects) and II (normal MPS subjects). From this table it can be seen that no significant difference was found between high and normal MPS subjects ($F = 0.736$, $df = 1/11$). In addition, Figure 4 illustrates the lack of a significant interaction which was found between subject groups and STM tests. Thus it is apparent from this figure that both high and normal MPS subjects performed similarly on the different short-term memory tests. Hypothesis five is therefore not rejected.

II. DISCUSSION

The results of this research have important clinical and theoretical implications with regard to retardate short-term memory processes and the techniques used to evaluate these processes. This section will discuss some of these implications.

Short-term memory differences. The fact that the oral commissions test differed significantly (that is, at the .001 level) from all other short-term memory tests is of particular interest when one compares the very nature of this test with the others. The oral commissions test was the only short-term memory test in which the stimuli were presented in organized, syntactical sequences. The remaining short-term memory tests utilized items, although some more

TABLE XI

MEAN MENTAL AGE SCORES, F SCORES, AND SIGNIFICANCE LEVELS AS A FUNCTION OF MUCOPOLYSACCHARIDE LEVEL: HIGH MPS SUBJECTS VERSUS NORMAL MPS SUBJECTS

	Subject Groups			
	High MPS Subjects	Normal MPS Subjects	F Score	Significance Level*
Mean Mental Age Score in Months	44.69	37.00	0.736	.587

*F larger than 4.84 (df = 1,11) required for significance at the .05 level of significance.

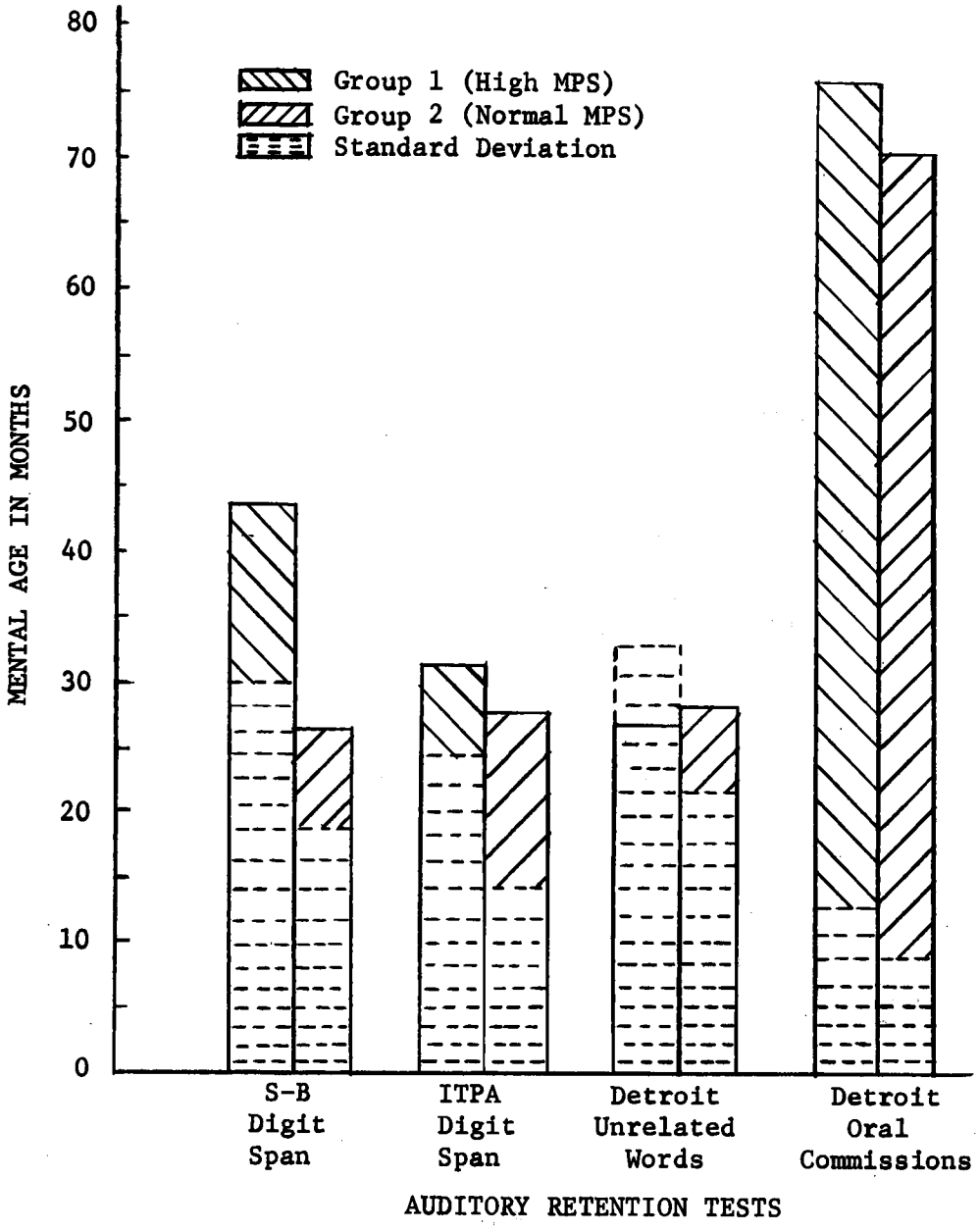

Figure 4. A comparison of subject groups (High and Normal MPS levels) on the four tests of auditory retention (presentation rates pooled).

propositional than others, which were random and unrelated (that is, no associative strengths between one item and the next). If, as Ellis (1970) suggests, the short-term memory limitations of many retardates are, in fact, due to an inability to organize incoming information, then perhaps the syntactical nature of the oral commissions stimuli served to preorganize the material and thus accounts for the significantly higher recall ability of the subjects in this study. In other words, it may be possible that the retarded subjects, while experiencing great difficulty in storing unrelated items, benefited significantly when such stimuli was organized for them into familiar sentences.

Another factor which may have had a meaningful effect upon test differences concerns the variation in tasks to be performed among the different short-term memory tests. While the digit span and unrelated words tests required verbal responses to indicate recall abilities, the oral commissions test demanded only that the subjects perform various physical commands. Thus, the latter required non-verbal responses. Since the Stanford-Binet Intelligence Scale, initially utilized to determine subject I.Q. level and mental age, does not distinguish between verbal and performance I.Q.'s (that is, both verbal and performance items are clustered together to determine a single intelligence quotient) it might be argued that the subjects in this study may have had verbal limitations affect their overall I.Q. and mental age scores. In such a case, the higher scores on the oral commissions test might thus be merely reflective of verbal and performance differences among the subjects examined. This was <u>not</u> believed to be

the case in this particular study. The psychologist who administered the Stanford-Binet carefully scrutinized those test areas which are considered to be verbal and non-verbal tasks and found no apparent trend among any of the subjects to perform consistently better on one particular type of task. The literature indicates that this generalized type of retardation is characteristic of mongolism, due to impaired brain development and other genetic problems (Ferrell, 1969; Tredgold, 1972). In addition, however, results from other non-verbal tests (such as Bender-Gestalt) were found to be supportive of the Stanford-Binet findings. Thus, the I.Q. and mental age scores from the Binet were believed to represent each subject's overall ability. This being so, it is not believed that the non-verbal nature of the tasks required by the oral commissions test was sufficient in itself to account for the significant difference which was found. The 6-2 mental age mean which was achieved on this test (almost three years above any other short-term memory, intelligence, or language test administered) is therefore attributed mainly to the differences in the test stimuli; more specifically, to the familiar, meaningful, and predictive organizational nature of the material presented.

As indicated earlier, results from the W.I.S.C. digit span test were excluded from the statistical analysis because of a failure of the majority of subjects to achieve the minimum mental age score. One critical reason for this was the inability of all but one subject to perform appropriately on the digits backwards portion of the test. Such results are consistent with the findings of Aten and Davis (1968), who observed that digits backwards was statistically discriminating between retarded subjects (minimal cerebral dysfunction) and normals.

Serial position and recall. Figure 5 summarizes the effect which the length of a given sequence has upon the frequency of correct recall for any given item within that sequence. It can be seen that as the length of a sequence increases, the frequency for recalling the first item presented decreases. All of the subjects in this study lost the ability to recall the first three items presented once the sequence exceeded five items in length. This would tend to support the limited buffer theory (Atkinson and Shiffrin, 1968), which holds that one of the beginning items of a series is removed to allow room for each newly presented item. Functioning much like a tape loop, as each new item is recorded, the next oldest is erased.

The frequency of recalling the last item in a sequence, in contrast, usually remained above .80 regardless of sequence length. As the series increased in its number of items, therefore, the subjects' apparent failure to utilize rehearsal or other types of organizational strategies became more evident in the sharp decline in the recall of the earliest items. These findings are similar to those of Ellis (see Figure 2, page 24).

The recency tendency (that is, the ability to better recall the last few items presented) found with unrelated words was not observed on all short-term memory tests. Serial position graphs from the oral commissions test indicate a definite primacy trend (that is, the ability to better recall the earliest presented items). These two opposite response patterns can be viewed in Figures 6 through 8. As each subject was performing command one, the remaining commands still to be performed may have been in the process of decaying, thus accounting

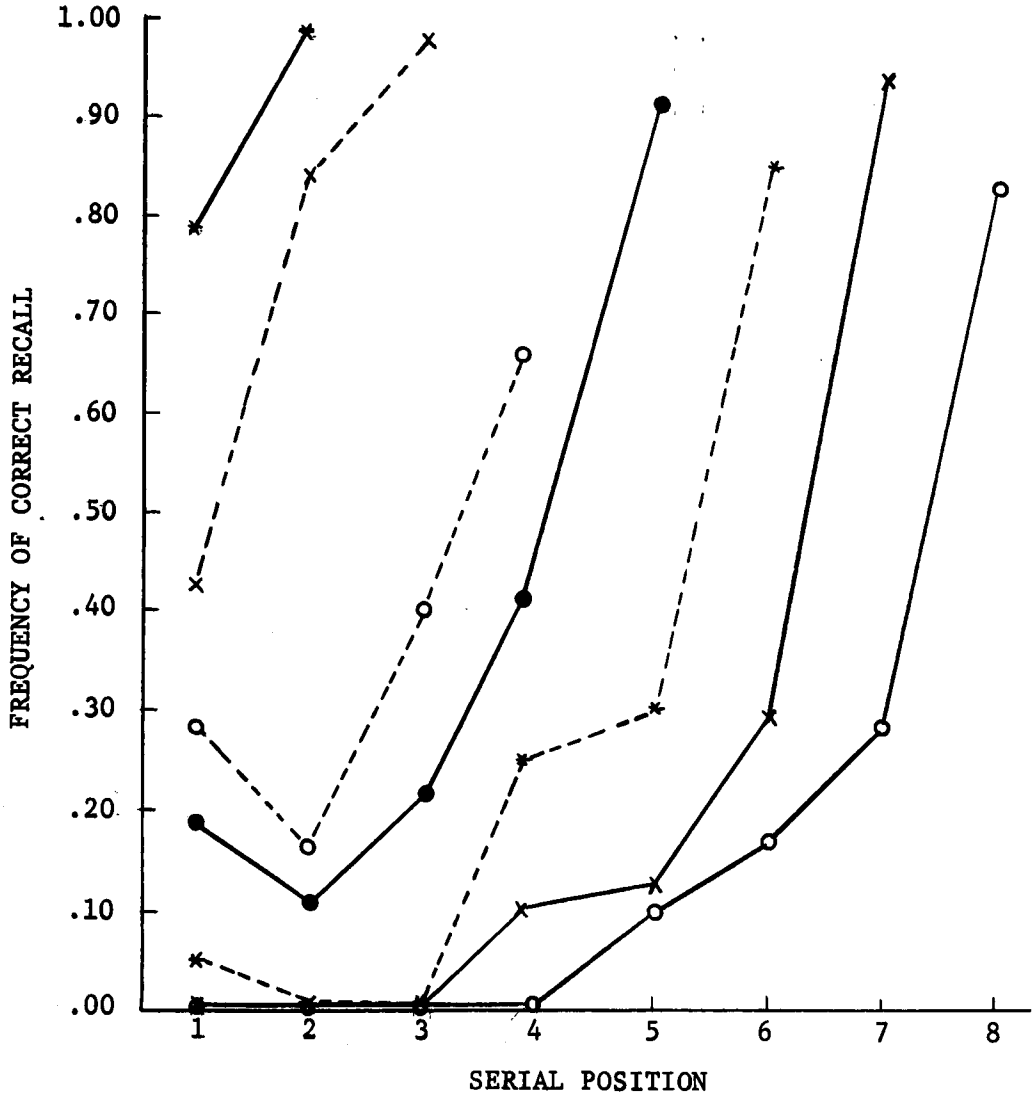

Figure 5. The frequency of correct recall for each word in sequences varying in length from two to eight unrelated words, and presented at the rate of one word per second.

- two word sequence
- three word sequence
- four word sequence
- five word sequence
- six word sequence
- seven word sequence
- eight word sequence

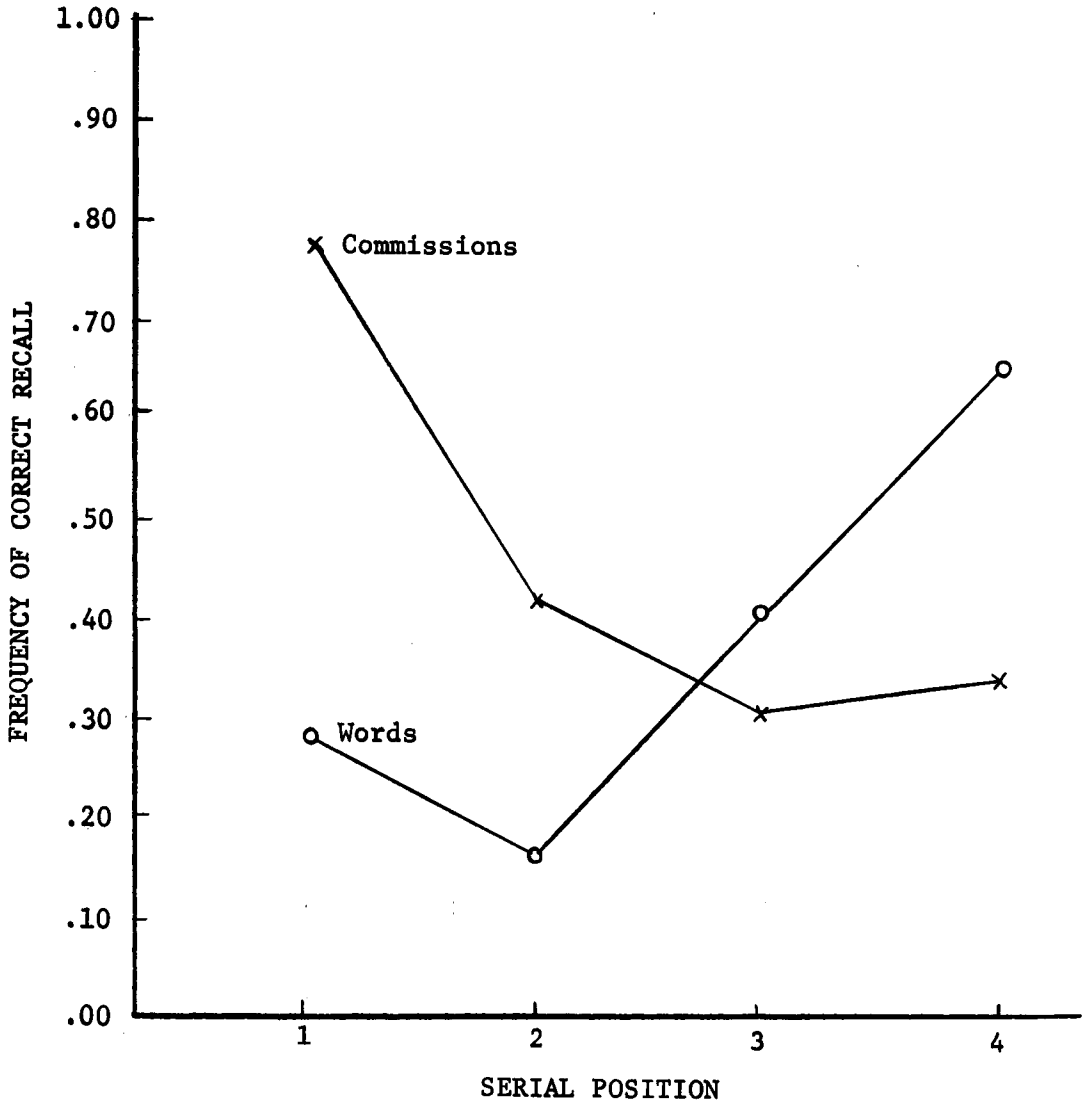

Figure 6. A comparison between oral commissions and unrelated words as a function of the frequency of correct recall for each item within a four item sequence.

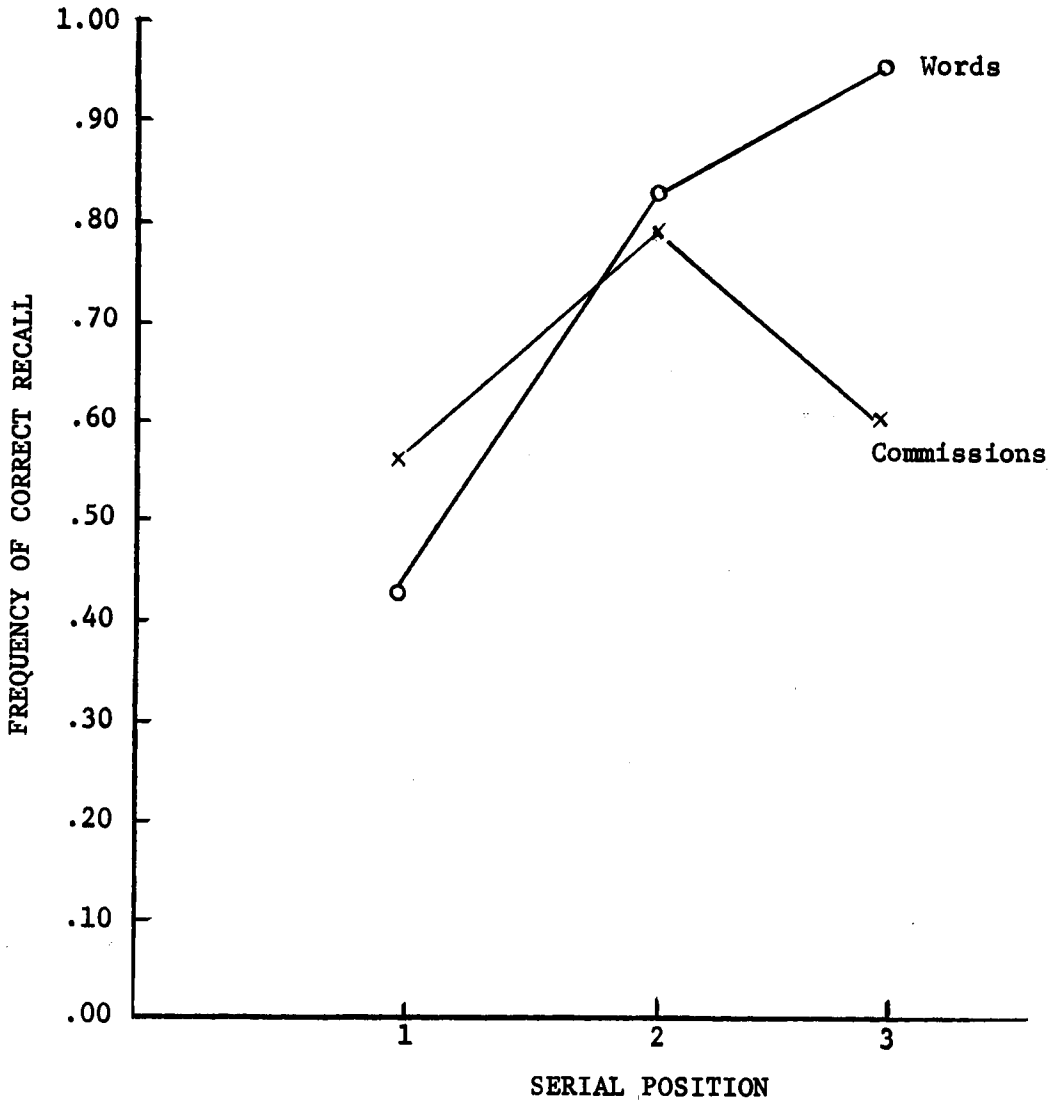

Figure 7. A comparison between oral commissions and unrelated words as a function of the frequency of correct recall for each item within a three item sequence.

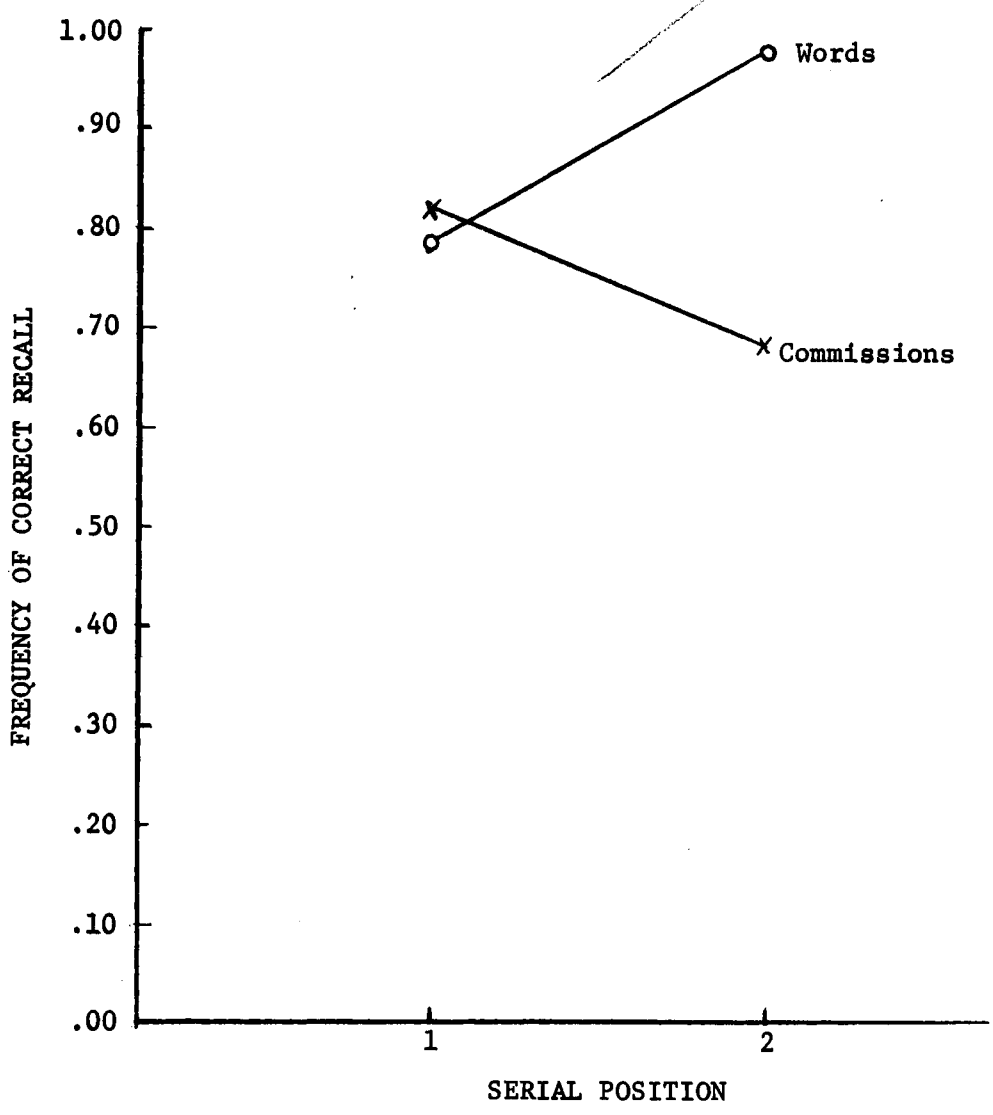

Figure 8. A comparison between oral commissions and unrelated words as a function of the frequency of correct recall for each item within a two item sequence.

for the loss of recall ability for these last items. This does not, however, answer the question of why the subjects chose to begin with command number one rather than the last command presented. This is particularly important considering the fact that it took approximately ten seconds longer to present the stimuli on the oral commissions test than on the unrelated words test. This extra time involved would logically make the first item which was presented that much further away from the point of recall, and therefore more difficult to retain. Recency should have been more evident on this test (oral commissions) than on any other short-term memory test. The primacy tendency which was observed, therefore, illustrates the power of linguistic stimuli. It also indicates that unrelated items do not appear to be stored or recalled in the same manner as syntactically organized information. Thus, tests involving the recall of unrelated items do not seem to assess the same processes as those utilizing more propositional stimuli.

Presentation rate. The lack of a significant difference in subject performance as a function of presentation rate is further evidence which suggests that certain retarded individuals may not utilize the larger inter-item intervals during slower presentation rates to rehearse and organize stimuli. Figures 9 through 15 illustrate that primacy (which is believed to be facilitated by rehearsal) did not improve with the slower rate. In fact, the mean spans for unrelated items were slightly increased with the faster rate, suggesting that the longer duration of the slower sequence allowed for some

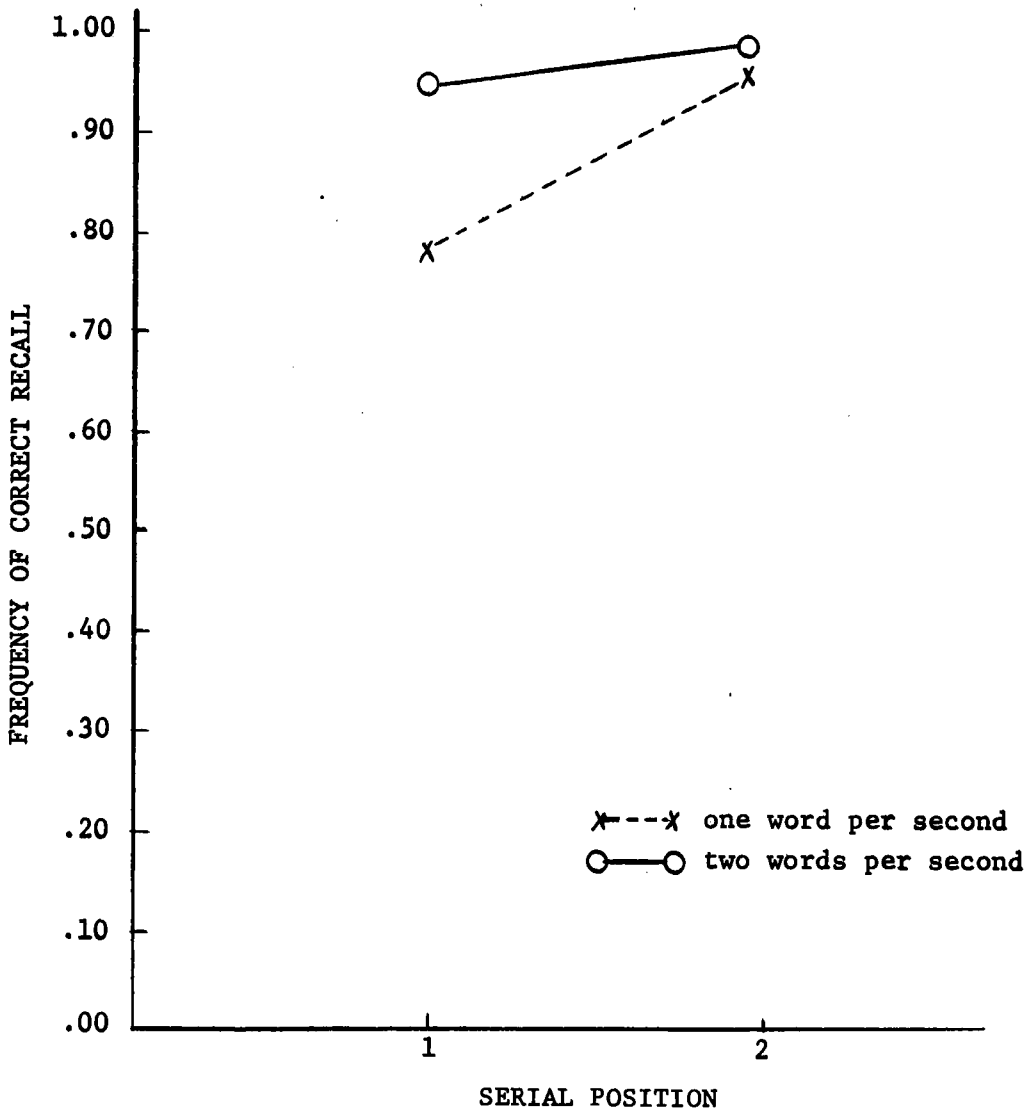

Figure 9. The effect which presentation rate has upon the frequency of correct recall for each word in a two word sequence.

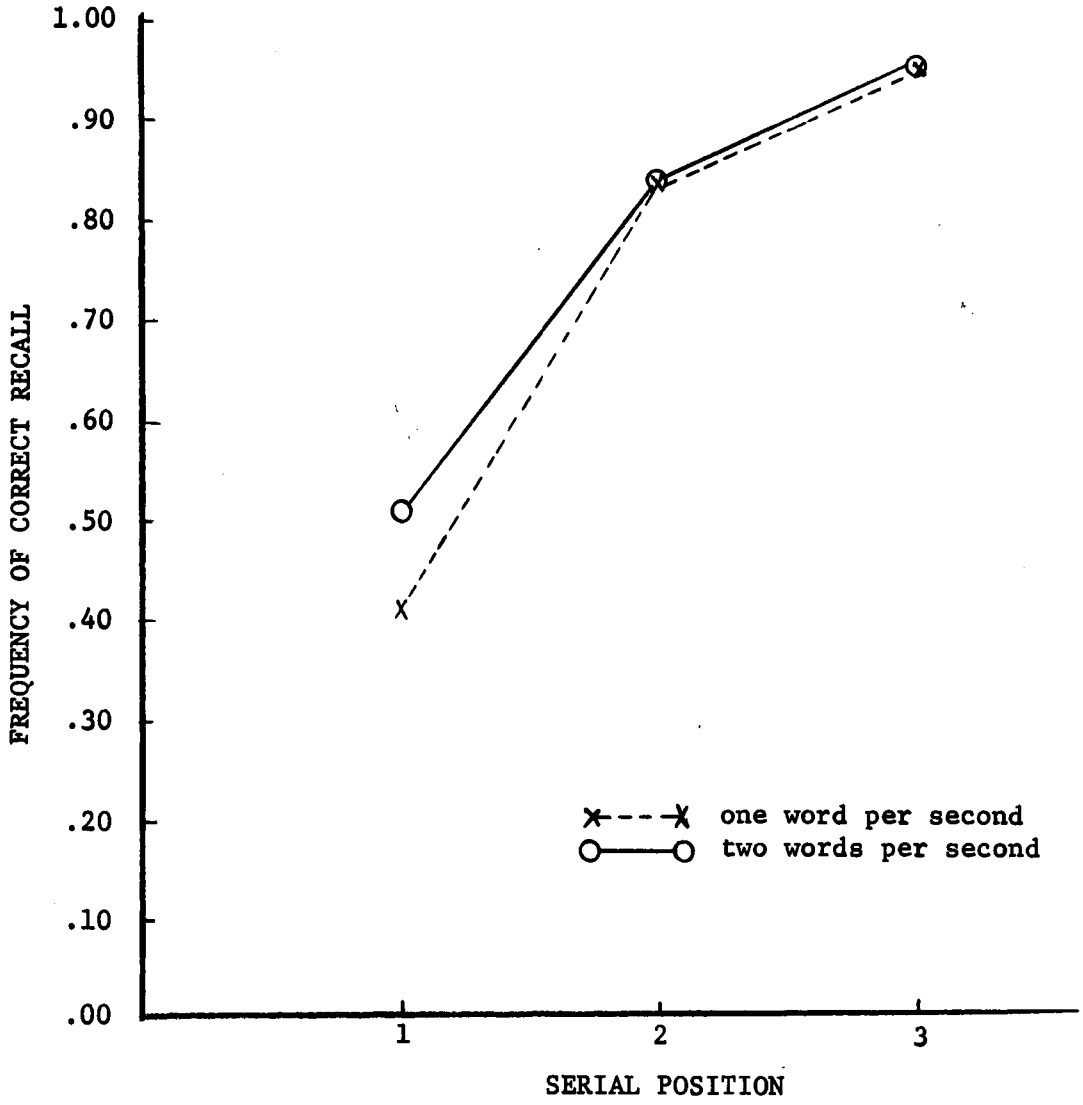

Figure 10. The effect which presentation rate has upon the frequency of correct recall for each word in a three word sequence.

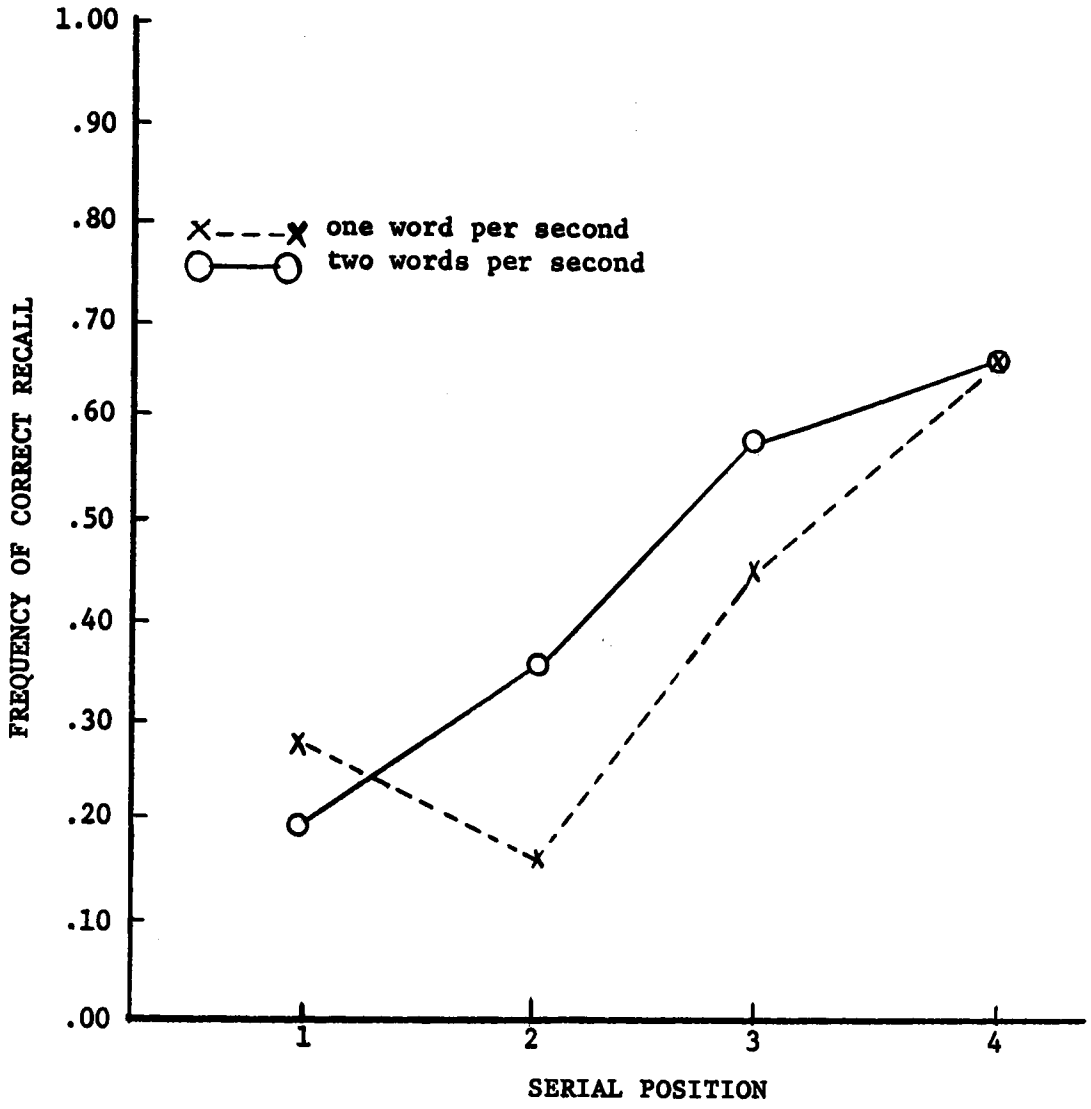

Figure 11. The effect which presentation rate has upon the frequency of correct recall for each word in a four word sequence.

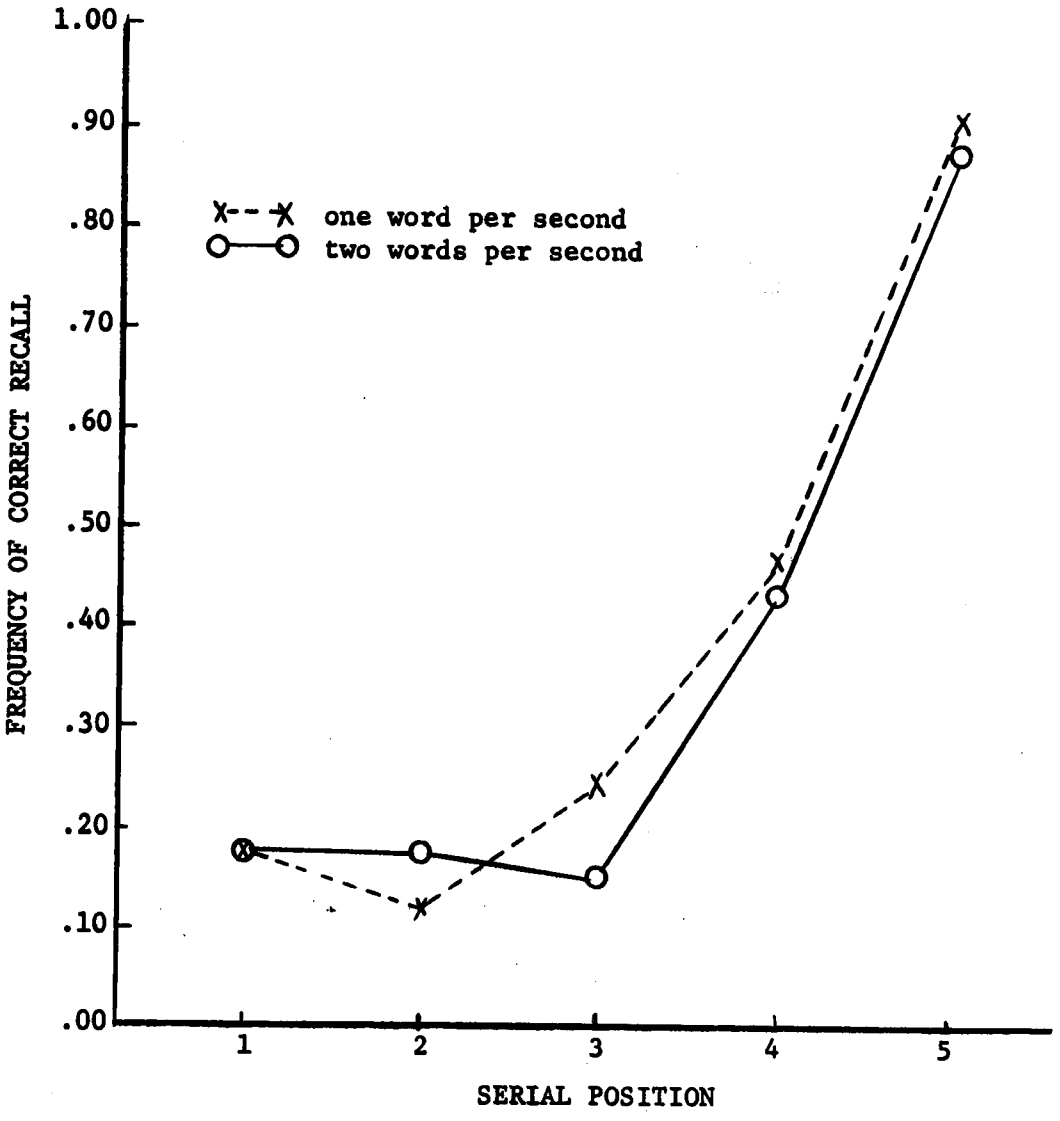

Figure 12. The effect which presentation rate has upon the frequency of correct recall for each word in a five word sequence.

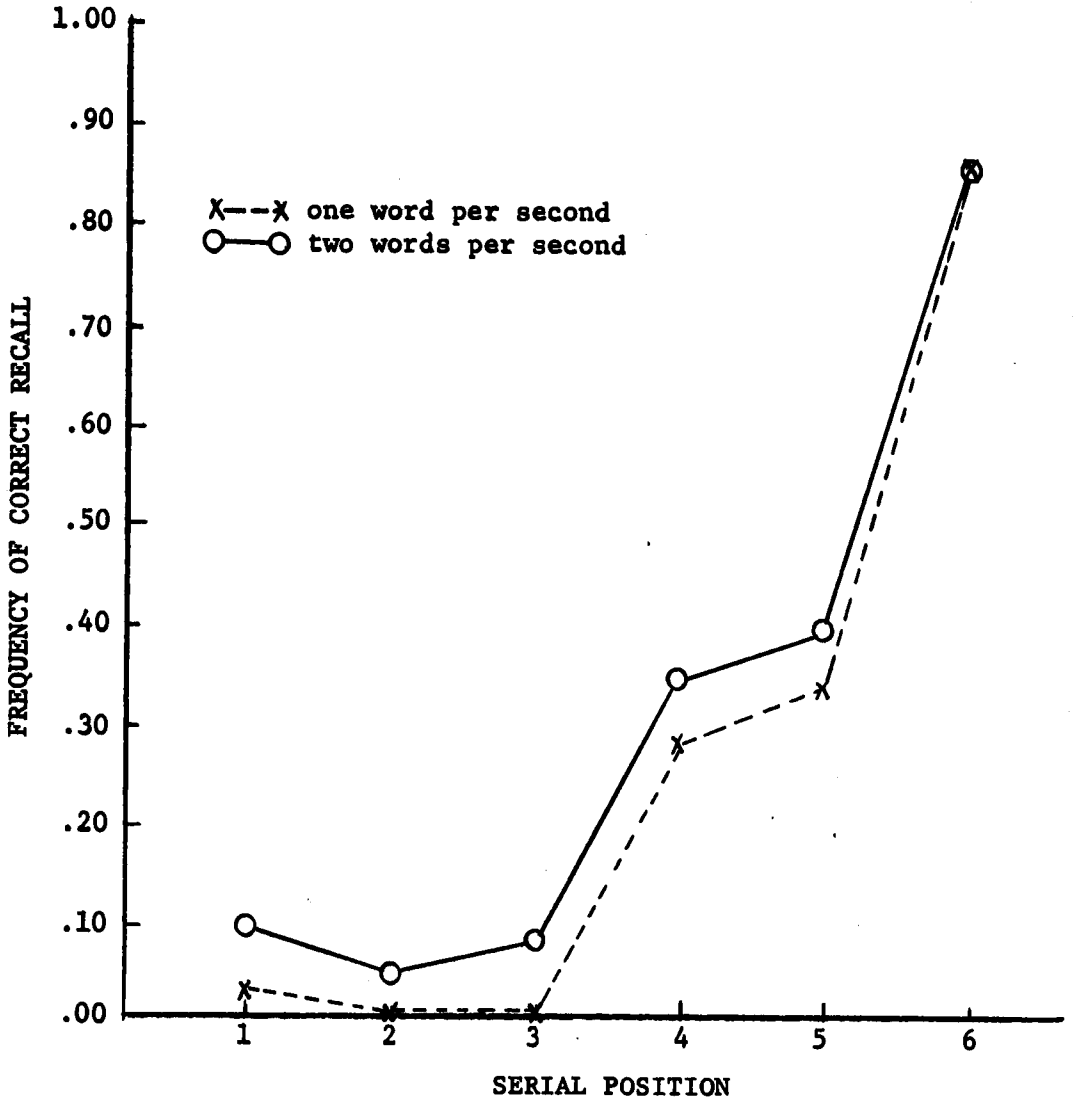

Figure 13. The effect which presentation rate has upon the frequency of correct recall for each word in a six word sequence.

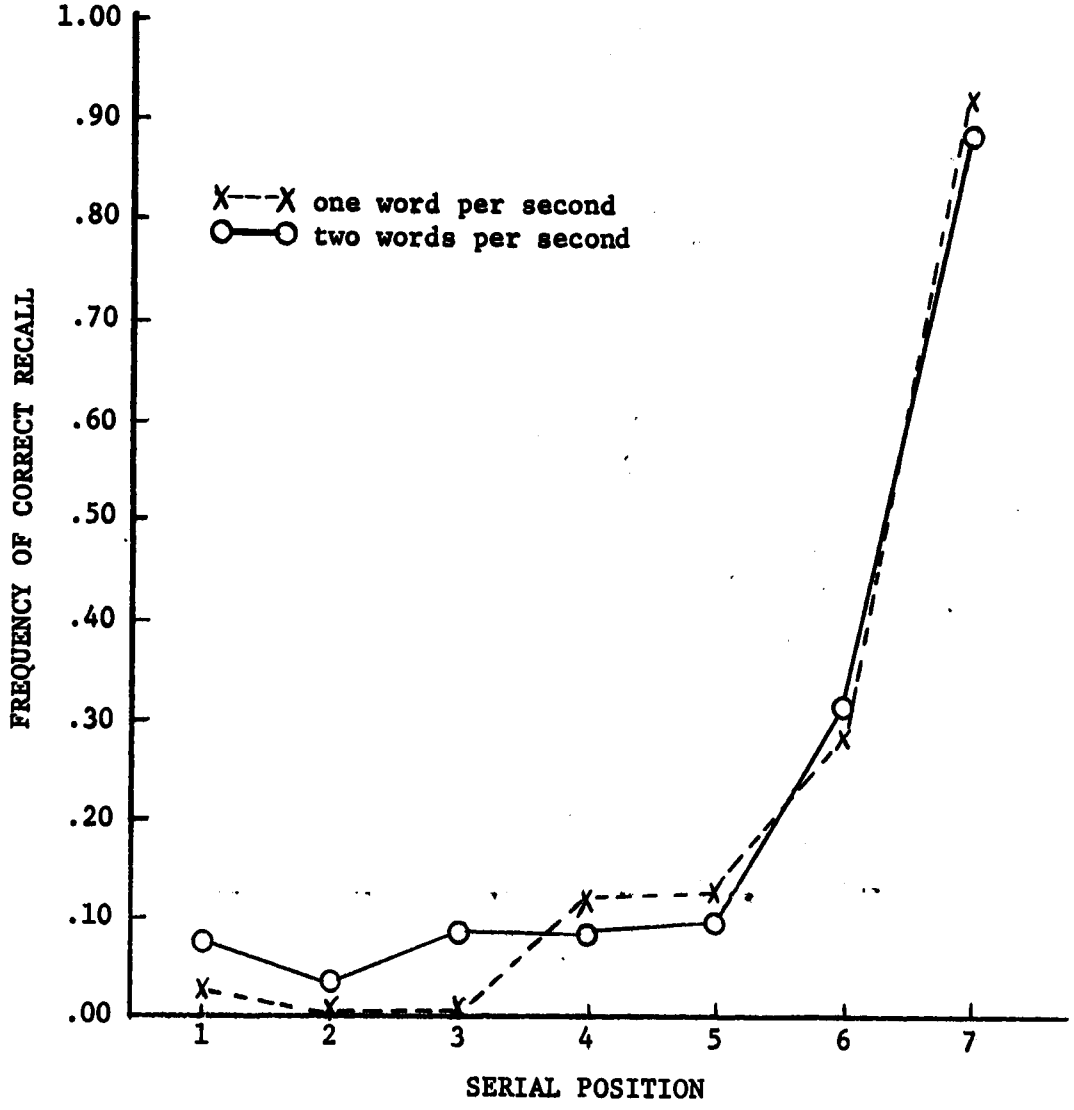

Figure 14. The effect which presentation rate has upon the frequency of correct recall for each word in a seven word sequence.

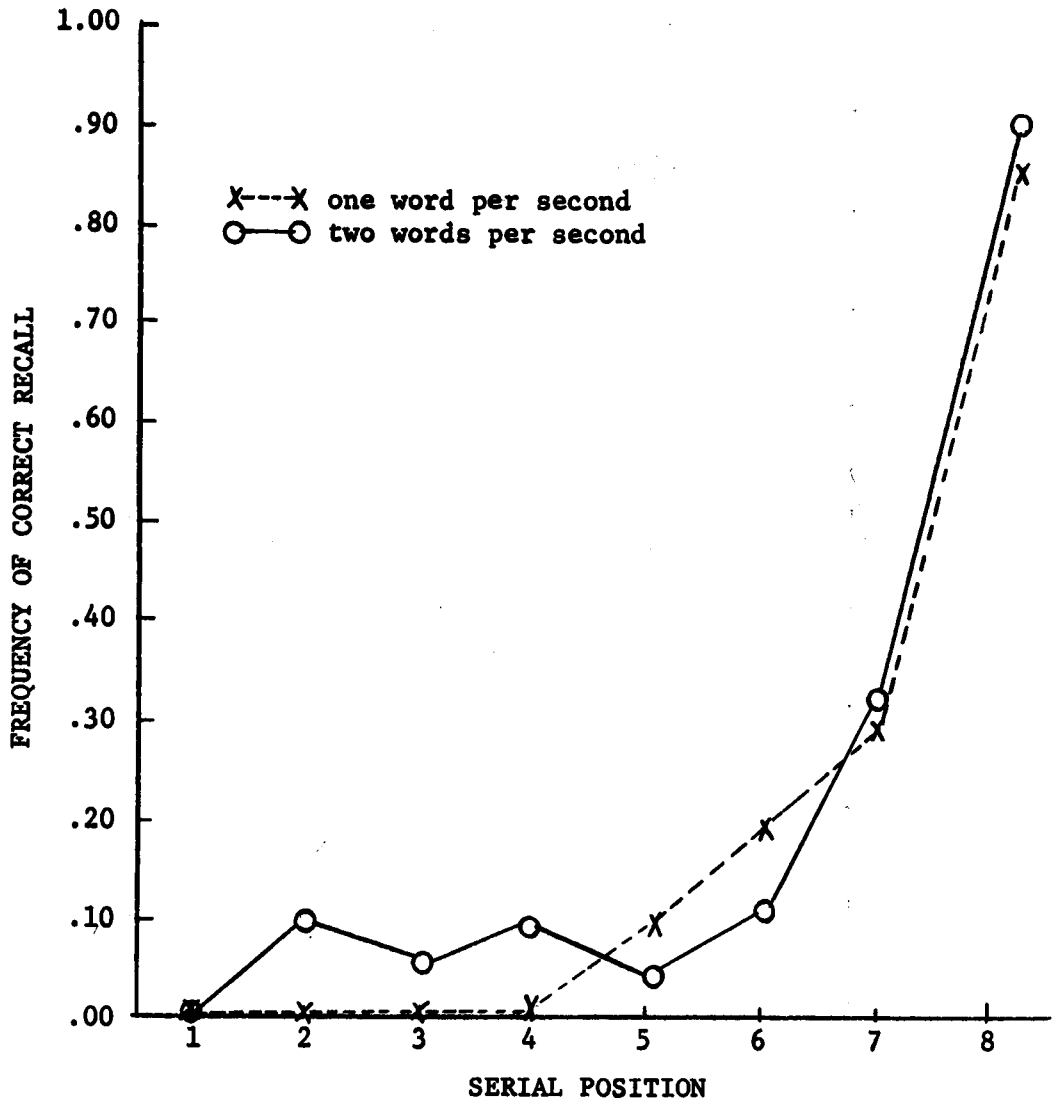

Figure 15. The effect which presentation rate has upon the frequency of correct recall for each word in an eight word sequence.

decay (which, again, was not the case for syntactically structured stimuli). These figures further demonstrate that the presentation rate had little effect on either primacy or recency, regardless of sequence length.

Short-term memory correlations with I.Q. and mental age. The results of this study would appear to imply that the ability to retain sequences of random digits, and perform various numbers of oral commands, relates very significantly to both an individual's level of intellectual functioning and his receptive vocabulary ability. It is still possible, however, for these two measures to assess two entirely different processes which, in this particular study, happen to be functioning at the same level because of the generalized type of retardation among the carefully controlled subjects. Such findings, therefore, might not occur within a different mentally retarded population.

Despite the fact that unrelated words are more propositional than digits (that is to say, words are more meaningful to the listener than digits), their failure to correlate with I.Q., mental age, and particularly receptive vocabulary age suggests possibly that the unrelated and random aspect of the stimuli is of greater importance than the meaningfulness within each item. Each subject, being asked to recall groups of words which were presented in sequences he had never been exposed to before, found this test to be the most difficult. Digits, on the other hand, have no proper order and, thus, do not violate any syntactical rules when they are randomized.

High versus normal MPS subjects. Several possibilities may account for the lack of a significant difference found between the high and normal MPS subjects in this study. The first of these is that the quantity chosen as the cut-off value for a high MPS level (that is, 125 mg/ml raw urine) may not be high enough. Perhaps a larger concentration, such as 200 mg/ml, is needed before the degenerative effects of the chemical imbalance takes place. If such were the case, then the MPS levels of the subjects in this study may have been too low to cause any significant change in the high MPS group.

A second possibility concerns an MPS measurement of a different nature. It may be that the quality of the MPS is equally as important as the quantity. This was suggested by McKusick (1966) in regard to the differential breakdown of the elements composing MPS. His suggestion was that it may be the level of Heparitin Sulfate within MPS that is the determining factor. Such an investigation of the MPS components was conducted on all of the high MPS subjects in this study. It was discovered that only two of the six subjects with high MPS levels had excesses of Heparitin Sulfate. These two subjects were the two lowest functioning subjects within the high MPS group. Although this N is obviously too limited to allow for any definitive conclusions, it does support the findings of McKusick and suggests, certainly, that this matter needs to be more thoroughly investigated before the question of MPS level may be adequately explained.

III. INTERPRETATION

Statistical and descriptive analysis of the data obtained in this investigation seems to indicate that, while auditory retention abilities are related to language and mental development, moderately retarded mongoloids store different kinds of information differently. That is, when the material to be stored is random and unrelated, these individuals achieve mental age scores which correspond, on the average, with their Stanford-Binet mental ages. However, if the test information is organized into syntactical sequences, mongoloids perform well above their Peabody and Stanford-Binet mental age scores. Similarly, when the information is unrelated, these subjects tend to recall only the last few items (recency). If presented in sentence form, on the other hand, the first items are recalled more often (primacy). Further analysis indicates that the meaningfulness of the individual items in a randomly organized sequence has little, if any, effect on the storage abilities of moderately retarded mongoloids. Improved recall results, however, once these items are organized into syntactical sequences. Evidently, the inter-item meaningfulness has a greater effect on storage than does the actual meaning of the items themselves.

Careful examination of serial position curves reveals that mongoloids are capable of storing fixed amounts of information regardless of the quantity presented. Once their initial memory span is surpassed by longer sequences, these subjects do not recall any more items, and often retain less. For example, if a subject was able to retain only three items in proper order, then he recalled three items

or less from sequences containing as many as eight items. The literature does not support this finding with normals. Deese and Hulse (1958, p. 269) report that once beyond a normal subject's initial memory span, he will recall more items, although there will be a decrease in the proportion of items stored. Such information suggests that moderately retarded mongoloids operate on a limited and fixed storage system.

The evidence that presentation rate does not significantly effect short-term memory performance implies that rehearsal and organizational techniques are not utilized by these individuals. Since rehearsal is one of the main strategies which holds information in short-term memory until it can be processed into long-term memory, mongoloids' apparent failure to rehearse may be an underlying factor in their limited receptive vocabularies.

Finally, the lack of a significant difference between groups of subjects with high and normal MPS levels suggests that the criteria selected to divide subjects (that is, 125 mg. MPS/ml. urine) was not critical. As previously indicated, perhaps the level of Heparitin Sulfate within the MPS is the factor which needs to be controlled. While this particular study was not designed to investigate this possibility, it was observed that the two lowest functioning subjects within the high MPS group possessed such excesses in Heparitin Sulfate. While this is not conclusive evidence (and the enzyme deficiency causing the excessive Heparitin Sulfate is unknown) it at least suggests that the findings of McKusick (1966) are in need of further study. In

either case, it appears that simply knowing the level of MPS of a Down's subject (within a range of approximately 0 to 200 mg.) does not provide sufficient evidence to suspect further retardation from degenerative brain damage.

CHAPTER V

SUMMARY AND CONCLUSIONS

I. SUMMARY

This study investigated the performance of moderately retarded mongoloid subjects on five specific tests measuring auditory retention abilities. These tests differed in the type of stimuli utilized, the rate at which items were presented, the task to be performed by the subject, and the manner in which each was scored. The relationship between the mental age scores from each of these tests and the I.Q. and language age for a given subject was also studied. Differences were examined between the performance of those subjects possessing a high level of mucopolysaccharides and those with a normal MPS concentration.

The subjects utilized in this study met the following criteria: (1) all were Caucasian; (2) all were between the ages of 5-0 and 12-6; (3) all possessed normal hearing acuity; (4) all had I.Q. scores which fell approximately within the moderately retarded range (that is, 36-51); (5) all were genetically diagnosed as having Trisomy 21, Down's Syndrome; and (6) one-half the subjects possessed high MPS levels and one-half possessed normal MPS levels. The subjects were divided into two groups on the basis of their MPS level. All subjects received each of the short-term auditory memory tests twice, differing the second time in the rate of presentation.

II. CONCLUSIONS

The following conclusions may be drawn from the data obtained from this study:

1. There is a significant difference in the performance of moderately retarded mongoloids on different auditory retention tests. This difference appears to be, for the most part, related to the meaningfulness and familiarity of the stimuli presented.

2. The rate of presentation of items to be recalled has no significant effect on the performance of moderately retarded mongoloids.

3. There are significant correlations between auditory retention abilities and I.Q. level, mental age, and receptive vocabulary age.

4. There are significant correlations among various auditory retention tests for moderately retarded mongoloids. Results from the oral commissions test correlated highly with the various digit span tests, but not with the unrelated words test.

5. There is no significant difference in the auditory retention abilities of moderately retarded mongoloids as a function of high and normal MPS levels.

6. Descriptive information indicates that the order and degree of recall appears to be largely dependent upon the organizational nature of the stimuli rather than the meaningfulness of each individual item.

III. CLINICAL AND EDUCATIONAL IMPLICATIONS

Because the criteria for subject selection was extremely rigid for the purpose of investigating a specific and controlled type of mental retardation, it would be unwise, indeed, to attempt to generalize experimental findings, at this time, to account for the entire mentally retarded population. Nevertheless, the results from this study do appear to indicate that the auditory retention abilities of moderately retarded mongoloids are directly related to their intelligence and receptive language development. When attempting to assess these memory processes as a possible cause for language retardation, it would appear that an oral commissions test (utilizing linguistic stimuli) is the most appropriate and accurate measure available. If the oral commissions test from the Detroit Tests of Learning Aptitude is to be used, great care should be taken to assure that the presentation rate follows the standardized directions (as this test appears to lose its correlation with mental age and I.Q. if a faster rate is adopted).

Unrelated items, such as digits and random word lists, seem to be stored differently by mongoloids (as indicated by the serial position of recall) and may, therefore, evaluate an entirely different and separate process. While the propositionality of the stimuli appears to represent an important factor in assessing auditory memory skills, the findings of this experiment seem to indicate that the meaningfulness of the relationship between test items (that is, the inter-item associations between digits or words) is far more critical than the meaningfulness of each individual item.

Several theoretical implications concerning the mechanisms of short-term memory have resulted from this investigation. Moderately retarded mongoloids appear to possess a limited buffer (S-system) which, when exceeded, tends to remove the earlier presented items in order to store the newer information. Because these individuals apparently do not rehearse incoming stimuli, their abilities of recall are limited to the last few items presented. These restrictions within the storage system appear to remain constant irrespective of the length or number of items contained in the stimuli. Such is not the case for normal individuals and may or may not be the case for other types of retardates. Clinically, this may be an important consideration in designing a therapy approach. Language and special educational programs have, in the past, operated on the premise that retarded individuals should be continuously and repeatedly bonbarded by tremendous quantities of multidimensional stimuli, with the hope that some of the information might be stored and processed. While such an approach might have its merits, it may indeed be inappropriate for certain types of retarded individuals who possess limited buffer systems. Mongoloids, who appear to be such individuals, would seem to benefit more from therapy which concentrated upon organizing and restricting the information load so that it fell within the storage span of each individual client. Such an information load would not, therefore, be increased until informal testing indicated that the items had been processed into long-term memory. Once again, these implications point out the need to identify and control for the specific etiology of the retardation, not only for research purposes but for the therapeutic approach as well.

IV. LIMITATIONS OF THE PRESENT STUDY

1. The number of subjects in each group were relatively small and, as a result, may have prevented a more thorough evaluation of the auditory retention processes of mongoloids with moderate levels of mental retardation.

2. While the short-term memory tests utilized were standardized and provided mental age norms, the lack of a control group prevented further comparison and generalization of results to the performance of normal and/or other types of mentally retarded subjects.

3. The use of the Stanford-Binet as a means for determining I.Q. level and mental age may have disguised possible differences in the verbal and performance abilities of the subjects in this study. An intelligence test such as the W.I.S.C., which differentiates between these two skills, might have made results more meaningful.

V. RECOMMENDATIONS FOR FURTHER STUDY

1. A similar study using a larger N and a control group of normal subjects and other genetically different, but uniquely grouped, retarded subjects.

2. A similar study comparing differences between recognition memory and recall memory of certain retardates to normal subjects. The purpose would be to further examine the bottleneck theory of retardation; that is, do retardates suffer more from an inability to retrieve rather than to recall information?

3. A similar study comparing differences in recall ability of normal and unique groups of retarded subjects as a function of

random versus organized stimuli. The same items which had been presented randomly could then be grouped in different ways (that is, rhythmic patterns, paired word association, and so forth) in an effort to determine the organizational nature of the short-term storage system for those particular retarded subjects. Differences between the retarded and normal subjects might give insight into why the storage system of the retarded group is limited.

4. A similar study which groups mongoloid subjects on a different MPS criteria than the one utilized in the present study. Perhaps subjects could be controlled for excesses of Heparitin Sulfate within the MPS content. Similarly, a higher level of MPS (that is, 200 mg/ml) might be chosen rather than 125 mg/ml..

5. A study which examines the long-term memory abilities of moderately retarded mongoloids. Such an investigation would provide evidence as to whether the storage limitations of these individuals were caused by restrictions in their STM or LTM or both.

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APPENDIX

APPENDIX

The University of Tennessee
MEMORIAL RESEARCH CENTER AND HOSPITAL
Birth Defects Evaluation Center
1924 Alcoa Highway
Knoxville, Tennessee 37920
(615) 971-3184

Dear _____:

Some new tests have recently been developed which we feel may be helpful in planning future language training for _____.

We would appreciate it if you could bring _____ to the Birth Defects Center at _____ on _____.

The results of this evaluation will be sent to the school which _____ is currently attending along with specific recommendations for a therapy program.

Sincerely yours,

Hiram McDade
Speech Pathologist

HMcD:cj

BIRTH DEFECTS EVALUATION CENTER
UNIVERSITY OF TENNESSEE
MEMORIAL RESEARCH CENTER AND HOSPITAL

RELEASE FORM

I hereby give my permission to the Birth Defects Evaluation Center to release psychological, ecuational and/or medical information about my child to any qualified professional agency or individual.

I also authorize other professional agencies or individuals to provide the Birth Defects Evaluation Center with any information it may request. All information is confidential and will be for professional use only.

_____
PATIENT'S NAME

_____
PARENT'S SIGNATURE

_____
DATE

INSTRUCTIONS FOR THE ADMINISTRATION OF THE DIGIT SPAN SUBTEST FROM THE WECHSLER INTELLIGENCE SCALE FOR CHILDREN

INTRODUCTION:

The Digit Span Test is one of 13 subtests on the WISC. It consists of two parts; digits forward and digits backwards. The numbers to be repeated are presented by the examiner at the rate of one per second.

STANDARD DIRECTIONS (part one):

The first part of this test (digits forward) begins with the examiner saying: I'M GOING TO SAY SOME NUMBERS TO YOU. I WANT YOU TO LISTEN VERY CAREFULLY AND TRY TO REMEMBER ALL OF THE NUMBERS SO THAT WHEN I STOP, YOU CAN SAY THEM RIGHT BACK TO ME JUST THE WAY I SAID THEM TO YOU. ARE YOU READY? LISTEN CAREFULLY: 3-8-6.

METHOD OF PRESENTATION (part one):

If the subject is successful, the examiner proceeds to the four digit series. If, however, the subject fails to correctly repeat the digits, trial II (a different series with the same number of digits) is attempted.

EXAMINER'S REVISED DIRECTIONS:

If the standard directions are not understood, or if the subject fails to perform correctly on the lowest level of items, the following revisions will be made: OKAY, LET'S TRY SOME EASIER ONES. SAY: 1. NOW SAY: 1-2. GOOD! NOW LISTEN VERY CAREFULLY, AND SAY: 2-1. VERY GOOD!! (proceed with the standard items).

It is important to note that all revised directions on all tests will be subject to modification as the situation demands. Each subject will be given as many "practice trials" as necessary until the examiner feels confident that the subject's performance on the standard test items will be optimal.

STANDARD DIRECTIONS (part two):

The second section of the Digit Span Test (digits backwards) begins with the examiner saying: NOW I'M GOING TO GIVE YOU SOME MORE NUMBERS, BUT THIS TIME WHEN I STOP I WANT YOU TO SAY THEM BACKWARDS. FOR EXAMPLE, IF I SAY 9-2-7, WHAT WOULD YOU SAY?

METHOD OF PRESENTATION (part two):

If the subjects response is incorrect, the examiner gives the correct response and another practice trial is presented. After two practice trials the test begins whether or not the subject was correct. If correct, the examiner begins with trial I of the three digit series; if incorrect, the trial I of the two digit series.

EXAMINER'S REVISED DIRECTIONS:

If the subject is unsuccessful, practice trials will be given utilizing two digit sequences instead of three. The examiner will say: LISTEN CAREFULLY. IF I SAY 1-2, YOU SAY 2-1, AND IF I SAY 2-3, YOU SAY 3-2, OKAY? LET'S TRY ONE. LISTEN: 4-5. (test items are begun when the subject can successfully repeat two digits reversed). If a subject cannot perform at this level, this part of the test will be stopped, with no credit given.

METHOD OF SCORING:

Each subject's total digit span score is computed by adding the scores of the two sections (digits forward plus digits backwards). The maximum score on Part I (digits forward) is nine, which would indicate that a subject with this score correctly repeated one of the nine-digit series. The maximum score on Part II (digits backwards) is eight. The total maximum score, therefore, is 17.

Parts I and II of this test each end when a subject is unsuccessful on both trials of the same number of digits. The largest series that he was able to correctly repeat is considered to be his score on that part. A subject, therefore, who is able to repeat no more than five digits forward and three digits backwards has a total digit span of eight. The Wechsler norms (see page 100) would thus assign this child a mental age of eight to nine years.

SUMMARY OF THE DIGIT SPAN TEST ITEMS FROM THE WECHSLER INTELLIGENCE SCALE FOR CHILDREN

DIGITS FORWARD:

SERIES	TRIAL I	TRIAL II
(3)	3-8-6	6-1-2
(4)	3-4-1-7	6-1-5-8
(5)	8-4-2-3-9	5-2-1-8-6
(6)	3-8-9-1-7-4	7-9-6-4-8-3
(7)	5-1-7-4-2-3-8	9-8-5-2-1-6-3
(8)	1-6-4-5-9-7-6-3	2-9-7-6-3-1-5-4
(9)	5-3-8-7-1-2-4-6-9	4-2-6-9-1-7-8-3-5

DIGITS BACKWARDS:

SERIES	TRIAL I	TRIAL II
(2)	2-5	6-3
(3)	5-7-4	2-5-9
(4)	7-2-9-6	8-4-9-3
(5)	4-1-3-5-7	9-7-8-5-2
(6)	1-6-5-2-9-8	3-6-7-1-9-4
(7)	8-5-9-2-3-4-2	4-5-7-9-2-8-1
(8)	6-9-1-6-3-2-5-8	3-1-7-9-5-4-8-2

TABLE XII

SUMMARY TABLE OF DIGIT SPAN SCORES AND CORRESPONDING MENTAL AGES FROM THE W.I.S.C.

Mental Age	Digit Span
5	5
5 1/2	-
6	6
6 1/2	7
7	-
7 1/2	-
8	8
8 1/2	-
9	-
9 1/2	9
10	-
10 1/2	-
11	-
11 1/2	-
12	10
12 1/2	-
13	-
13 1/2	-
14	-
14 1/2	11
15	-
15 1/2	-

INSTRUCTIONS FOR THE ADMINISTRATION OF THE DIGIT SPAN PORTIONS FROM THE STANFORD-BINET INTELLIGENCE SCALE

INTRODUCTION:

Unlike the other tests in this study, the digit span items which have been abstracted from the Stanford-Binet were not originally organized as separate subtests, per se. Instead, the digit span items represent only one of several areas to be tested at each age level; the assumption being that each digit sequence corresponds to a given mental age ability.

STANDARD DIRECTIONS (part one):

The examiner begins the test by saying: LISTEN: SAY 4-2. NOW SAY . . . . . (begin test items).

EXAMINER'S REVISED DIRECTIONS (part one):

If the subject is unable to correctly repeat the two-digit practice sequence, or if the subject does not appear to understand the directions, the examiner will present the following revised directions: I WANT YOU TO LISTEN VERY CAREFULLY AND SAY EXACTLY WHAT I SAY. READY? SAY: 5. GOOD! NOW SAY: 4-2. VERY GOOD! CAN YOU SAY: . . . .(begin test items)?

METHOD OF PRESENTATION:

Each series is presented at the rate of one digit per second with equal emphasis on each digit. A subject has only one attempt at getting a given series correct (order is important). Three separate digit sequences of the same length, however, may be presented if

necessary. The correct recall of any one of these is considered acceptable for giving the subject credit for that corresponding mental age level.

STANDARD DIRECTIONS (part two):

For the digits-reversed portion of this test, the examiner instructs the subject: I'M GOING TO SAY SOME NUMBERS AND I WANT YOU TO SAY THEM BACK TO ME AS SOON AS I FINISH, BUT THIS TIME I WANT YOU TO SAY THEM BACKWARDS. FOR EXAMPLE, IF I SHOULD SAY: 4-1-5, YOU WOULD SAY: 5-1-4. READY NOW? LISTEN CAREFULLY AND BE SURE TO SAY THEM BACKWARDS. (Examiner begins test items).

EXAMINER'S REVISED DIRECTIONS (part two):

In addition to the above standard directions, the examiner will allow the subjects to practice repeating two-digit sequences in reverse before the actual test items are presented. Each subject will be given as many of these practice items as necessary until he fully understands exactly what is going to be expected of him, or until it becomes apparent that he will not be able to perform this type of task.

METHOD OF SCORING:

A subject attains a mental age value dependent upon the most difficult sequence he was able to recall (the items being arranged in the order of their degree of difficulty). The norms for this test may be found on page 104.

STANFORD-BINET DIGIT SPAN TEST

Record Form

1. Two Digits Forward

   a) 4-7 b) 6-3 c) 5-8

2. Three Digits Forward

   a) 6-4-1 b) 3-5-2 c) 8-3-7

3. Four Digits Forward

   a) 4-7-2-9 b) 3-8-5-2 c) 7-2-6-1

4. Five Digits Forward

   a) 3-1-8-5-9 b) 4-8-3-2-7 c) 9-6-1-8-3

5. Six Digits Forward

   a) 4-7-3-8-5-9 b) 5-2-9-7-4-6 c) 7-2-8-3-9-4

6. Three Digits Reversed

   a) 2-9-5 b) 8-1-6 c) 4-7-3

7. Four Digits Reversed

   a) 8-5-2-6 b) 4-9-3-7 c) 3-6-9-2

8. Five Digits Reversed

   a) 8-1-3-7-9 b) 6-9-5-8-2 c) 9-2-5-1-8

9. Six Digits Reversed

   a) 4-7-1-9-5-2 b) 5-8-3-6-9-4 c) 7-5-2-6-1-8

TABLE XIII

MENTAL AGE EQUIVALENTS FOR DIGIT SPANS
FROM THE STANFORD-BINET
INTELLIGENCE SCALE

Digit Span	Stanford-Binet Mental Age
Two Digits Forward	2 1/2 yrs.
Three Digits Forward	3 yrs.
Four Digits Forward	4 1/2 yrs.
Five Digits Forward	7 yrs.
Three Digits Reversed	7 yrs.
Four Digits Reversed	9 yrs.
Six Digits Forward	10 yrs.
Five Digits Reversed	12 yrs.
Six Digits Reversed	Superior Adult

INSTRUCTIONS FOR THE ADMINISTRATION OF THE AUDITORY SEQUENTIAL MEMORY SUBTEST FROM THE I.T.P.A

INTRODUCTION:

The Auditory Sequential Memory Test is one of 12 subtests comprising the Illinois Test of Psycholinguistic Abilities. This particular portion of the I.T.P.A. involves the recall of various digit sequences, differing in length, which are presented to the subject at the rate of two digits per second. Unlkie other digit span tests, the examiner drops his voice when presenting the last digit of a series.

STANDARD DIRECTIONS:

The examiner begins by saying: LISTEN. SAY: 2-2. If the subject is unsuccessful, the examiner uses single digits and then returns to "2-2" and "2-1." Once the subject is successful on the two demonstration items, the examiner begins the test items. Any time a sequence is missed on the first trial, the examiner responds; NOT QUITE. LISTEN AGAIN (repeats the sequence).

METHOD OF PRESENTATION:

The starred or "sampling items" are presented first. When a subject misses either of a pair on the first trial, a second trial is given and the sampling ends. From this point, the examiner proceeds backwards until three consecutively listed items have been passed on the first trial. This is the "Basal Score." The examiner then returns to where the first failure in sampling occurred and continues testing forward until two consecutively listed items are failed on both trials.

METHOD OF SCORING:

A sequence is not considered to be correct unless it is recalled in the exact order in which it was originally presented. Two points are given for each item passed on the first trial, while one point is awarded for each item passed on the second trial. Failure on both trials yields no points for that sequence. The score on this test is the total number of points accumulated. The maximum score is 56 points (see page 108).

AUDITORY SEQUENTIAL MEMORY

(Digit Span)

Record Form
From The I.T.P.A.

*Demonstration

a. 2-2

b. 2-1

SCORE _____

		1st	2nd
*	1. 9-1		
*	2. 7-9		
*	3. 8-1-1		
*	4. 6-4-9		
	5. 5-2-8		
*	6. 2-7-3-3		
*	7. 6-3-5-1		
	8. 8-2-9-3		
	9. 1-6-8-5		
*	10. 4-7-3-9-9		
*	11. 6-1-4-2-8		
	12. 1-5-2-9-6		
	13. 7-3-1-8-4		
	14. 5-9-6-2-7		
*	15. 7-4-8-3-5-5		
*	16. 2-9-6-1-8-3		
	17. 5-2-4-9-3-6		
	18. 4-7-3-8-1-5		
	19. 6-9-5-7-2-8		
*	20. 3-6-1-9-2-7-7		
*	21. 5-3-6-9-7-8-2		
	22. 8-1-6-2-5-9-3		
	23. 2-7-4-1-8-3-6		
	24. 4-9-6-3-5-7-1		
*	25. 3-1-9-2-7-4-8-8		
*	26. 9-6-3-8-5-1-7-2		
	27. 4-7-3-1-6-2-9-5		
	28. 8-2-5-9-3-6-4-1		

Basal: 3 consecutive successes
Ceiling: 2 consecutive failures

TABLE XIV

SUMMARY TABLE OF RAW SCORES AND AGE NORMS FROM THE I.T.P.A.

Age Norms	Raw Score
2-0	3
2-2	4
2-5	5
2-7	6
2-10	7
3-0	8
3-2	9
3-5	10
3-7	11
3-10	12
4-0	13
4-2	14
4-5	15
4-8	16
4-10	17
5-0	18
5-3	19
5-6	20
5-8	21
6-0	22
6-3	23
6-6	24
6-10	25
7-2	26
7-7	27
7-11	28
8-4	29
8-8	30
9-2	31
9-10	32
10-3	33

INSTRUCTIONS FOR THE ADMINISTRATION OF THE ORAL COMMISSIONS SUBTEST FROM THE DETROIT TESTS OF LEARNING APTITUDE

INTRODUCTION:

The Oral Commissions Test represents another of the nine subtests from the Detroit Tests of Learning Aptitude. It is composed of four paired sentences (each commanding the subject to perform various tasks) which vary in content from one to four-part commissions.

STANDARD DIRECTIONS:

The examiner begins by saying: I'M GOING TO TELL YOU SOME THINGS TO DO. YOU LISTEN AND DO JUST WHAT I TELL YOU TO DO AFTER I GET THROUGH. LISTEN . . . (proceed with test items).

METHOD OF PRESENTATION:

The commissions are presented slowly allowing ". . . from ten to fifteen seconds for the pupil to do what is required of him in the test" (Baker, 1959). All suggestions, such as nodding or gazing toward any of the objects, are to be avoided. All four pairs of commissions are given.

The materials utilized in this test are a book, pencil, penny, and piece of paper.

METHOD OF SCORING:

One point is awarded for each commission correctly executed in the proper order with respect to the other commissions of the same group. For example, if three commissions are performed in the

order of 1-3-2, 3-1-2, 2-3-1, or 2-1-3, two points are given. The maximum score on this test is 20 points. (See page 112 for age norms).

ORAL COMMISSIONS

Record Form
From The Detroit Tests Of
Learning Aptitude

Score.....

1a Show me the window.

b Stand up straight.

2a Walk to the door; then bring me that book.

b Walk to the window; then put this book on a chair.

3a Put this pencil on the table; then open the door; then fold your hands behind you.

b Bring me that piece of paper; then close the door; then stand on this line.

4a Walk to the window; then tap the floor once with your foot; then put this penny in my hand; then tell me your name.

b Open the door; then put a mark on this paper; then bring me that book; then stand by the window.

TABLE XV

SUMMARY TABLE OF SCORES AND CORRESPONDING MENTAL AGES FROM THE ORAL COMMISSIONS PORTION OF THE DETROIT TESTS OF LEARNING APTITUDE

Mental Age	Score
3-0	2
3-3	2
3-6	3
3-9	4
4-0	4
4-3	5
4-6	6
4-9	6
5-0	7
5-3	8
5-6	9
5-9	10
6-0	11
6-3	12
6-6	13
6-9	14
7-0	15
7-3	16
7-6	17
7-9	18
8-0	19
8-3	20

INSTRUCTIONS FOR THE ADMINISTRATION OF THE AUDITORY ATTENTION SPAN FOR UNRELATED WORDS SUBTEST OF THE DETROIT TESTS OF LEARNING APTITUDE

INTRODUCTION:

The Auditory Attention Span for Unrelated Words Test is one of nine subtests on the Detroit Tests of Learning Aptitude. It consists of eight paired strings of words which are presented to the subject at the rate of one word per second. Unlike the digit span tests, no requirement in the order of recall is made.

STANDARD DIRECTIONS:

The examiner begins the test by saying: I'M GOING TO SAY SOME WORDS TO YOU. LISTEN CAREFULLY AND WHEN I GET ALL THROUGH I WANT YOU TO SAY JUST WHAT I SAID. TELL THE WORDS IN THE SAME ORDER IF YOU CAN. DO YOU UNDERSTAND? NOW LISTEN -- SAY "CAT--ICE." After the subject responds, the next series is begun.

EXAMINER'S REVISED DIRECTIONS:

If a subject cannot correctly repeat the two-word sequence, the examiner will say: OKAY, TRY THIS ONE: "CAR." GOOD! NOW SAY: "WATER." VERY GOOD! NOW CAN YOU SAY: "CAR--WATER?" (if successful, proceed with the test).

METHOD OF PRESENTATION:

Responses are recorded by placing a number above each word indicating the order in which the subject repeats them;

1 2 3
eg. man -- horse -- song.

This procedure is repeated throughout the entire group of words, regardless of how many a given subject misses.

METHOD OF SCORING:

Two kinds of scores are calculated on this test. The "Simple Score" is determined by giving one point credit for each word recalled ". . . in any order for all spans" (Baker, 1959). The maximum simple score is 70. The "Weighted Score" is calculated by multiplying the number of words correct in each span by the total number of words in that span. The maximum weighted score is 406 points. (See page 116 for age norms).

AUDITORY ATTENTION SPAN FOR UNRELATED WORDS

Record Form From The Detroit Tests Of Learning Aptitude

Score: Simple .....

Weighted .....

2a cat ice

2b dog ship

3a man horse song

3b pen girl cow

4a cart bird desk road

4b chair hen book vest

5a head milk dress oats night

5b pipe west fence coat mule

6a fish clock heart sun box frog

6b stone blot freeze door cut white

7a skirt plant friends east tub barn hair

7b mud vase north ten rain cross shoe

8a ear boat key pig south knob ink rope

8b flour skate fan spend lamp wool axe toad

TABLE XVI

SUMMARY TABLE OF SIMPLE AND WEIGHTED SCORES AND CORRESPONDING MENTAL AGES FROM AUDITORY ATTENTION SPAN PORTION OF THE DETROIT TESTS OF LEARNING APTITUDE

Mental Age	Total Simple	Total Weighted
3-0	27	133-137
3-3	28	138-142
3-6	29	143-147
3-9	30	148-152
4-0	31	153-157
4-3	32	158-162
4-6	33	163-167
4-9	34	168-172
5-0	35	173-177
5-3	36	178-182
5-6	36	183-187
5-9	37	188-192
6-0	38	193-197
6-3	39	198-202
6-6	40	203-207
6-9	40	208-212
7-0	41	213-216
7-3	41	217-220
7-6	42	221-224
7-9	43	225-228
8-0	44	229-232
8-3	45	233-236
8-6	46	237-240
8-9	47	241-244
9-0	47	245-247
9-3	48	248-250
9-6	48	251-253
9-9	49	254-256
10-0	49	257-259
10-3	50	260-262
10-6	51	263-265
10-9	51	266-268

TABLE XVI (continued)

Mental Age	Total Simple	Total Weighted
11-0	52	269-271
11-3	53	272-274
11-6	53	275-277
11-9	54	278-280
12-0	54	281-284
12-3	55	285-288
12-6	55	289-292
12-9	56	293-296
13-0	56	297-300
13-3	57	301-304
13-6	57	305-308
13-9	58	309-312
14-0	58	313-316
14-3	59	317-319
14-6	59	320-322
14-9	60	323-325
15-0	60	326-328
15-3	61	329-331
15-6	61	332-334
15-9	62	335-337
16-0	62	338-340
16-3	63	341-343
16-6	63	344-347
16-9	64	348-351
17-0	64	352-355
17-3	65	356-359
17-6	65	360-363
17-9	66	364-367
18-0	66	368-371
18-3	67	372-375
18-6	67	376-379
18-9	68	380-385
19-0	69	386-405

TABLE XVII

SUMMARY OF MENTAL AGE EQUIVALENTS FOR ALL SUBJECTS
ON THE FIVE TESTS OF AUDITORY RETENTION

Subject	MPS Group	Mental Age in Months									
		W.I.S.C. Digits		Stanford-Binet Digits		I.T.P.A. Digits		Unrelated Words		Oral Commissions	
		*1/Sec.	2/Sec.	*1/Sec.	2/Sec.	1/Sec.	*2/Sec.	*1/Sec.	2/Sec.	*Spaced	Massed
S_1	High	<60	<60	30	30	<24	26	60	63	75	75
S_2	High	<60	<60	30	30	24	31	<36	<36	84	69
S_3	High	60	72	84	120	60	86	<36	93	99	87
S_4	High	<60	<60	30	30	<24	<24	<36	<36	66	69
S_5	High	<60	<60	36	36	41	41	<36	<36	87	87
S_6	High	<60	<60	36	36	36	36	60	54	66	51
S_7	Normal	<60	<60	36	36	26	41	<36	39	66	72
S_8	Normal	<60	<60	30	36	24	29	<36	<36	69	63
S_9	Normal	78	78	54	54	48	53	57	57	90	81
S_{10}	Normal	<60	<60	30	30	26	38	<36	<36	72	81

TABLE XVII (continued)

Subject	MPS Group	Mental Age in Months									
		W.I.S.C. Digits		Stanford-Binet Digits		I.T.P.A. Digits		Unrelated Words		Oral Commissions	
		*1/Sec.	2/Sec.	*1/Sec.	2/Sec.	1/Sec.	*2/Sec.	*1/Sec.	2/Sec.	*Spaced	Massed
S_{11}	Normal	<60	<60	36	36	29	26	48	42	75	78
S_{12}	Normal	<60	<60	<30	30	<24	26	36	36	63	63
S_{13}	Normal	<60	<60	<30	30	<24	26	36	36	63	63

*Standard method of presentation.

VITA

Hiram Lonsdale McDade III was born in Cleveland, Ohio, on November 11, 1947. He attended Normandy Elementary School in Bay Village, Ohio and graduated from Mountain Lakes High School in Mountain Lakes, New Jersey in June 1966. He did undergraduate work at Baldwin-Wallace College in Berea, Ohio, and received a Bachelor of Arts degree in Public Address and Forensics in June 1970.

In March 1971, he began studies in Speech Pathology and Audiology at The University of Tennessee and entered their graduate program in January 1972. He received his Master of Arts degree with a major in Speech Pathology in March 1974.