AUDITORY SEQUENCING AS IT PERTAINS TO THE LEARNING DISABLED CHILD

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CURRICULUM STUDIORUM

Marilyn Hayman (nee Beavers) was born January 16, 1937, in Watrous, Saskatchewan to Hazel and Buford Beavers. Her early education was in Xena Public School and Watrous High School, Watrous, Saskatchewan from which she graduated in 1954. Two years at the University of Saskatchewan, Saskatoon, Saskatchewan were devoted to teacher training. She received the Bachelor of Arts from Carleton University, Ottawa, Ontario in 1970. In 1971, she graduated with the degree of Master of Education from the University of Ottawa, Ottawa, Ontario. She entered the Master of Arts program in Psychopedagogy at the University of Ottawa in 1973.

TABLE OF CONTENTS

LIST OF TABLES

INTRODUCTION

> To label a child is to stamp a cross on him; to lack understanding of his disabilities is to let him carry that invisible cross alone and unaided.[1]

During the past decade there has been an increasing interest in the study of learning disabilities. This has resulted not only in new terminology with all the attendant problems of interpretation, but also hopefully in a deeper understanding of a child's difficulties in the light of normative growth. Of the some thirty-eight different labels used to describe disorders of learning such as specific learning disability, perceptual dysfunction, minimal brain dysfunction, cerebral dysfunction, neurological impairment, dyslexia, alexia, perceptual handicap and so on, the term "learning disabilities" is the most widely used and perhaps the best to describe a wide range of learning problems.

The operational definition of the term accepted for the current research is as follows: Children with learning disabilities are those who have adequate mental or intellectual ability, whose sensory processes are intact, whose emotional stability is within the normal range, but who experience deficits in their receptive, integrative and expressive processes. These

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1 Marilyn Hayman, "The Learning Disabled Child", Unpublished manuscript presented to the Faculty of Education of the University of Ottawa, Ontario, 1974, p. 18.

deficits frequently manifest themselves in perception, conceptualization, language, memory and control of attention, impulse and motor function problems. Accordingly special classes have been created to help afflicted children cope with their disabilities.

Educational theorists express many different points of view as to the principal causative factors. Frostig[2] has been most influential in the study of disabilities in visual functioning, frequently indicated by errors of reversal, right-left orientation confusion and inability to perceive spatial features. Cruikshank[3] has associated inability to learn with inability to focus attention on relevant stimuli. The widely publicized theories of Delacatto[4] have been criticized by those in the educational field who reject his theories of repatterning brain impulses to bypass those areas of the brain which have been

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2 Marianne Frostig, Learning Problems in the Classroom, Prevention and Remediation, London, Grune and Stratton, 1973, x-353 p.

3 William M. Cruikshank, "The Education of Children with Specific Learning Disabilities", Education of Exceptional Children and Youth, ed. William M. Cruikshank and G. Orville Johnson, Englewood Cliffs, Prentice Hall, 1958, p. 242-289.

4 C. H. Delacatto, The Diagnosis and Treatment of Speech and Reading Disorders, Springfield, Thomas, 1963, x-188 p.

damaged. Kephart[5] and Rabinovitch[6] claim learning disabled children have a basic disturbed pattern of neurological disorganization and recommend patterning as close to grade one as possible. There is also an educational hypothesis which links the auditory perceptual functioning of the child directly to his ability to read. Research in this regard has in fact indicated that an auditory dysfunction is sometimes reflected in the inability to sequentialize and maintain the structure of an auditory perception.

In the current research, the term "auditory sequencing" has been used to refer to the ability to hold in mind the structure of the stimuli which has been presented via the sense of hearing, and hold it long enough to re-auditorize it in reverse order.

The purpose of the current research is to show that children who are severely hampered in their ability to read share a deficiency in the ability to sequence at the most basic level of immediate recall of sounds, and to suggest that it is

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5 N. C. Kephart, "Perceptual Motor Aspects of Learning Disabilities", Educating Children with Learning Disabilities, ed. E. Frierson and W. Barbe, New York, Appleton Century Crofts, 1967, p. 405-413.

6 Ralph Rabinovitch, "Reading and Learning Disabilities", American Handbook of Psychiatry, ed. S. Sute, New York, Basic Books, 1959, p. 857-869.

the ability to hear and retain the necessary sequence of sounds which largely determines a child's ability to read.

The current research is introduced with a review of the pertinent literature on auditory sequencing as it relates to learning disabilities, together with the rationale which leads to the statement of the problem and the research hypothesis. Chapter two outlines the experimental design and includes a discussion of the sample, the measuring instruments, the collection and description of the data, and the plan of the analysis. The results of testing of the hypothesis by means of a multivariate analysis are presented in chapter three. The fourth chapter discusses the results of the testing in the light of the research findings cited in the first part of the thesis, and includes a summary of the research and a statement of conclusions.

CHAPTER I

AUDITORY SEQUENCING AS IT RELATES TO LEARNING DISABILITIES

"Why can't I read? Why me?" The child with learning disabilities is deeply concerned with this question and deserves an answer.

It is the purpose of this chapter to explore some of the theories and research which deal with auditory sequencing as it relates to learning disabilities. The research examines the developmental aspects of auditory functioning to see how deficits in auditory sequencing fit into the pattern of learning dysfunctions. To determine where auditory sequencing fits into the total process of communication, which includes reading, several aspects of two different theories of communication are presented. Finally those research studies which deal with auditory sequencing as it relates to reading are examined. The hypothesis of the current study follows from this search of the literature.

1. Development of Auditory Functioning

In order to understand abnormalities in auditory sequencing, the development expected in the normal child must be clearly established and used as a basis for comprehension of dysfunction. Despite the number of children with auditory deficiencies, almost all babies begin life with intact peripheral organs for hearing. Even a new-born infant will give a startle response to loud noises in his vicinity.

However, the development of auditory capacities is just beginning. Calanchini and Trout[1] list the development of auditory capacities as follows:

1) The recognition and identification of sounds are of prime importance to a new-born child. From the first initial startle response to a loud noise, he passes through successive growth stages with respect to sensitivity until he can recognize and identify the speech vibrations of his mother's whisper or his brother's call.

2) As his ability to discriminate between sounds increases, a child perceives differences in pitch, quality and intensity, until "bad" and "bed" with their respective intonations represent two very different things to him.

3) In order to identify a word as a synthesized whole, a child is required to recognize sounds, discriminate differences, and isolate and code specific auditory symbols. At nine months, a baby normally progresses to a point where it can associate definite articulate sounds with a person, an object or an action.

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1 Philip R. Calanchini and Susan Struve Trout, "The Neurology of Learning Disabilities", Learning Disorders in Children; Diagnosis, Medication, Education, ed. Lester Tarnapol, Boston, Little and Brown, 1971, p. 207-250.

A good example would be the association of the word "dog" with that species of animal.

4) To isolate and analyze components of the whole and place them in proper sequence, a child must first have mastered three previous steps. He must be able to recognize, discriminate, code classify and store symbols in the brain before he can hold in mind a sequence of symbols. A child also learns to blend a sequence of sounds into a word pattern to form his own words, and to deal with groups of sounds taken together. "Bring me the teddy bear" may be translated into the child's jargon of "Me bring teddy bear", demonstrating the mastery of sound recognition, discrimination, coding of specific symbols and finally classification and holding in mind, in order to repeat a series of symbols.

Studies in the field of linguistics by Brown and Bellugi[2], Chomsky[3] and Lenneberg[4], indicate that in learning to talk a child must understand, remember word sequences, manipulate

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2 Roger Brown and Ursula Bellugi, "Three Processes in the Child's Acquisition of Syntax", New Directions in the Study of Language, ed. Eric H. Lenneberg, Cambridge, MIT Press, 1964, p. 131-161.

3 N. Chomsky, The Acquisition of Syntax in Children from Five to Ten, Cambridge, MIT Press, 1969, p. 1-20.

4 Eric J. Lenneberg, ed. New Directions in the Study of Language, Cambridge, MIT Press, 1964, p. 65-85.

symbols and generate the principles of sentence structure. Even though syntax involves much more than simple sequencing of sound patterns, this aspect cannot be overlooked. Although a child cannot remember every sentence he hears, he must hold in mind the sequences of patterns, and make abstractions about the relationship of sounds to words and words to sentences in order to generate sequences of words on his own. He must be able to sequentialize and maintain the structure of an auditory perception, which is another way of saying that he must be able to sequence auditorially.

Having achieved normal development, the auditory mechanism functions in three different ways. It provides: 1) sensitivity to the intensity of sound; 2) fine discriminations of sound differences: and 3) recognition of the temporal pattern of sound, or a recall of auditory sequences in order to re-auditorize them.

If there are impairments in the central pathways of the brain which affect recognition and temporal management of auditory stimuli, normal input will not be reinforced and profound sensory deprivation can result, even though the sense organs for hearing are normal in every other respect. For example:

1) If a child fails to develop sensitivity to the intensity of sound, this is commonly referred to as deafness and is the most readily identifiable of auditory handicaps.

2) Lack of discrimination between the differences in sound patterns is less readily identified, even though there is some indication that such difficulties arise simultaneously with problems in articulation.[5] Delayed speech facility is one of the earliest and most sensitive indicators of learning difficulties, but lack of auditory discrimination may not be identified until a child first attempts to read and has trouble hearing the difference between "bed", "bad" and "bid", or in rhyming one word with another.

3) If a child cannot retain what follows what in verbal sequence, he has a deficit in auditory sequencing. His speech will probably be delayed and he will likely display immature syntax, disorganization, cluttering and articulation problems. He may well appear confused and restless, because if he hears but does not interpret what he hears, he cannot structure his auditory world to sort out and associate sounds with experience.

Without this ability to sequentialize speech sounds, talking is as unintelligible as a foreign language. Understanding the sounds of human speech is dependent upon the discrimination of temporal sound patterns. Hard express his view:

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5 M. C. Templin, Certain Language Skills in Children, Minneapolis, University of Minnesota, 1957, p. 140-141.

> It seems entirely reasonable that this is what is involved in much of dyslexia (....) an inadequacy in the reinforcing mechanisms which make process, pattern formation and retention possible and productive.[6]

The review of current theories has thus far focused on the development of auditory functioning and on disruptions in normal comprehension. The child with a deficit in auditory sequencing may be considered stupid, stubborn, defiant or slow even before he is faced with the additional job of superimposing a visual symbol system (reading) upon the already shaky auditory symbol system.

2. Some Aspects of the Communication Process

Because the current study is attempting to equate a deficit in serial organization of auditory stimuli with disabilities in learning, an examination of various aspects of two theoretical constructs follows. Kirk, McCarthy and Kirk's work on the Illinois Test of Psycholinguistic Abilities[7] and

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6 William G. Hard, "Dyslexia in Relation to Diagnostic Methodology in Hearing and Speech Disorders", Reading Disability, ed. John Money, Baltimore, John Hopkins Press, 1966, p. 175.

7 S. A. Kirk, J. J. McCarthy and W. D. Kirk, Illinois Test of Psycholinguistic Abilities, revised edition, Urbana University of Illinois Press, 1968.

Johnson and Myklebust's work with learning disabilities[8] are most relevant to a discussion of those aspects of communication which relate deficits in auditory sequencing to the more general picture of communication.

McCarthy and Kirk, who developed the original Illinois Test of Psycholinguistic Abilities (ITPA)[9], were strongly influenced by Osgood's work on psycholinguistics[10] dealing with communication. They adopted Osgood's communication model[11] which distinguishes primarily between two kinds of learning: 1) primary learning, involving those stimulus objects which are capable of eliciting instrumental response sequences without any mediational process, or which cause the original formation of sensory integrations (perception), motor integrations (skills) and representational processes (meanings); and 2) secondary learning, involving signs which elicit mediating processes.

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8 Doris J. Johnson and Helmer R. Myklebust, Learning Disabilities, Educational Principles and Practices, New York, Grune and Stratton, 1967, x-336 p.

9 J. J. McCarthy and S. Kirk, "Illinois Test of Psycholinguistic Abilities", Urbana, Institute for Research on Exceptional Children, 1961.

10 Charles E. Osgood, Method and Theory in Experimental Psychology, New York, Oxford University Press, 1953, p. 362-412.

11 Ibid., p. 362-412.

Using this same basic rationale and following extensive testing of the experimental ITPA, Kirk, McCarthy and Kirk published a revised version of the ITPA in which they attempt to analyse those subskills of intellectual functioning which pertain to psycholinguistic skills.[12] However, in attempting to understand the underlying psychology of language as well as the nature of language itself to determine why some children have difficulty in learning, Kirk, McCarthy and Kirk devised their own theoretical construct which is most clearly outlined in a book by Kirk and Kirk[13].

The Clinical Model of the ITPA hypothesizes that there are three dimensions involved in communication: 1) levels of organizations; 2) channels of communication; and 3) processes of communication. Each dimension views communication from a different perspective.

1) Of the three dimensions, the first which deals with levels of organization is particularly relevant to the understanding of auditory dysfunction. The habits of communication which have been developed within an individual may operate at two levels of organization. The response is either automatic

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12 Kirk, McCarthy and Kirk, Op. Cit.

13 Samuel A. Kirk and Winifred D. Kirk, Psycholinguistic Learning Disabilities: Diagnosis and Remediation, Chicago, University of Illinois Press, 1971, p. 19-23.

(as the unintentional acquisition of correct grammatical sequencing) or representational (as a response which requires some mediating process within the person such as categorization). Automatic learning, the basic process involved in the daily work and play of the growing child, equates with the ability to sequentialize and maintain the structure of an auditory perception.

2) The second dimension involved in communication comprises the input and output routes through which the content of communication flows and is called channels of communication. While stimuli may be brought into the communication centre either visually or auditorially and retransmitted through motor or vocal expression, the current study is concerned with only the auditory-vocal and auditory-motor channels.

3) The third dimension encompasses processes of communication broken down into three basic aspects controlling the acquisition and use of language: reception (decoding), association (mediation or organization) and expression (encoding). Auditory and visual memory processes are isolated within this framework.

Although the ITPA cannot be used for the current research because of its age limits (2½ to 9½ years), the theoretical rationale provides an explicit interpretation of the relation of auditory sequencing to communication skills and hence reading.

The ITPA subtest, which is similar to those used in the current research, is the test for auditory sequential memory. Auditory sequential memory refers to the ability to remember and correctly repeat a sequence of symbols just heard, a process very similar to that required by the Wechsler Intelligence Scale for Children's[14] digit span subtest used in the current study. If a child scores very low on this test, he may have difficulty 1) attending to the details of auditory stimuli; 2) repeating what he has heard and attended to; and 3) storing and retrieving information.[15] In summary, Kirk, McCarthy and Kirk postulate that auditory sequencing is an automatic process which deals with the auditory channel and is one of the processes of receptive sequential memory.

Whereas Kirk, McCarthy and Kirk have contributed much to testing and diagnosis of communication problems, Johnson and Myklebust have contributed equally to understanding, diagnosis and treatment of communication disorders.[16] Their work with groups of children who have a psychoneurological learning disability is based on an assumption of brain dysfunction and

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14 D. Wechsler,"Wechsler Intelligence Scale for Children", New York, Psychological Corporation, 1949.

15 Wilma Jo Bush and Marian Taylor Giles, Aids to Psycholinguistic Teaching, Columbus, Charles E. Merrill, 1969, p. 191.

16 Doris J. Johnson and Helmer R. Myklebust, Learning Disabilities, Educational Principles and Practices, New York, Grune and Stratton, 1969, x-336 p.

emphasizes the necessity of a medical-psychological-educational team approach to diagnosis and remediation.

Johnson and Myklebust assume that the following must be intact in order for normal learning to occur: 1) psychological language functions; 2) the peripheral nervous system; and 3) the central nervous sytem.[17]

a. The psychological language functions may be divided into three parts:

(1) receptive language, which is the ability to understand others;

(2) inner language, which enables the child to think and use verbal imagery (that is, the use of words to internalize symbolic meaning and integrate words and experience); and

(3) expressive language, which is the ability to speak and to write.

These three psychic processes are fundamental to the study and evaluation of all learning deviations, since language normally develops in a fixed sequential pattern. Disruption of any of these three processes disrupts the fixed sequential pattern and hence the ability to learn.

The learning disabled child does not appear to have a chance to consolidate any one of these steps before he is expected to cope with the next progressive step; thus if the serial

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17 Johnson and Myklebust, Op. Cit., p. 8-17.

organization of auditory stimuli is deficient, the ability to assimilate inner language and to express himself must also suffer.

b. Another prerequisite to normal learning is the intactness of the peripheral nervous system, or normally functioning visual, auditory, tactile and kinesthetic modes. If one of these modalities is not working, some of the peripheral systems may suffer from overloading or underloading, thereby interfering with the learning process.

c. The third requisite for normal learning is that the central nervous system functions normally. Dysfunctions in this area are those with which Johnson and Myklebust have been most concerned in their research on learning disabilities. Within the central nervous system, there are semi-autonomous systems which are responsible for the process of learning: within these semi-autonomous systems there are three types and four levels of learning.

Those three types of semi-autonomous systems are: (1) intraneurosensory learning, which is the involvement of only one modality in the input, integration and output of information. It is this type of learning which is involved in the serial organization of auditory stimuli. Because it is not concerned with learning in the visual, tactile or kinesthetic areas, the testing of auditory sequencing in the current research deals specifically with the auditory modality.

(2) interneurosensory learning, which is a cross-modal type of learning involving a transducing mechanism which translates information from one system to another. Dyslexia is an example of a cross-modal deficiency involving at least two modalities and possibly more;

(3) integrative learning, which requires that the semi-autonomous systems function as a unit and that all types of information are used. Johnson and Myklebust call this acquisition of meaning and ability to conceptualize "inner Language".[18] A child who reads easily integrates all modalities easily; conversely a child with a reading problem probably has difficulty integrating various modalities.

Perhaps the finding which has most relevance for the current research is Johnson and Myklebust's postulation that one of the three systems could be overloaded in that when there are too many simultaneous stimuli from all the modalities, the functioning of one modality may interfere with that of another.[19] Therefore, a child might learn best by focusing only on the auditory processes to the exclusion of the other processes. The child with an auditory sequencing problem has a central nervous system deficit which is an intraneurosensory type of

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18 Johnson and Myklebust, Op. Cit., p. 178.

19 Ibid., p. 76.

problem involving only the auditory modality.

According to Johnson and Myklebust, the four levels of cognitive processes are:

(1) perceptual, which involves the recognition of sound;

(2) imagery, which is the ability to call to mind that which has been heard;

(3) symbolic process, or the ability to reconstruct that which has been heard; and

(4) conceptualization and generalization, or the ability to sequence and categorize experience. A child should be able to group ideas that have logical relationships and groups things in proper sequential order.[20]

A learning disability may disrupt the cognitive processes at any level and must be evaluated by type and level to determine what remediation is needed. Auditory sequencing ability is required at the most basic level of perception in order to receive a word or group of words in the sequence in which they were presented. As the child matures, gaps in sequencing ability will cause problems at the imagery, symbolic, and finally, concept and generalization levels.

Johnson and Myklebust see reading as being primarily a visual symbol system, but believe that many auditory integrations are essential for complete acquisition [21] and list methods

20 Ibid., p. 32-44. 21 Ibid., p. 173-190.

of remediation. If a child fails to remember a sequence of letters or sounds, he will experience difficulty in reading and spelling. While children with difficulty in auditory sequencing may attain good reading ability, spelling will continue to lag behind. Johnson and Myklebust contend that, "Reading is a visual symbol system superimposed on auditory language."[22] Thus they continue to stress the importance of the auditory language system in the learning disabled child while emphasizing the reciprocal relationships between visual, auditory and expressive channels in verbal and motor activities.

To recapitulate, the examination of two theoretical constructs has highlighted those aspects which can shed light on the role of auditory sequencing in the communication process. Kirk, McCarthy and Kirk's work (as outlined in Kirk and Kirk)[23] calls auditory sequencing an automatic process dealing with the auditory channel and considers it one of the processes of receptive sequential memory. Johnson and Myklebust[24] contend that a dysfunction in auditory sequencing involves the 1) psychological language system in that auditory reception complicates

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22 Johnson and Myklebust, Op. Cit., p. 173.

23 Kirk and Kirk, Op. Cit., p. 19-23.

24 Johnson and Myklebust, Op. Cit., x-178.

inner and expressive language functioning; and 2) the central nervous system in an intraneurosensory type of problem involving the auditory channel. In other words, the dysfunction causes problems at the perceptual and imagery level of the learning process which inhibits learning at the symbolic and conceptualization levels.

If reading, then, is to be considered one of the aspects of communication, and if the aforementioned theorists regard auditory sequencing as one of the prerequisites to communication, it seems reasonable to propose that auditory sequencing does indeed have an influence on a child's ability to read.

3. Relevant Research Studies

There is a plethora of current literature which pertains to the temporal sequencing of auditory perception in relation to reading ability. Particularly relevant are studies which deal with the temporal sequencing of non-speech sounds, studies and experimental work in serial order, auditory versus visual sequencing and studies which deal with the digit span subtest of the Wechsler Intelligence Scale for Children (WISC).[25]

Although a facet of auditory functioning other than sequencing is involved, extensive investigation of the role of

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25 D. Wechsler, "Wechsler Intelligence Scale for Children", New York, Psychological Corporation, 1949.

auditory discrimination in reading by Wepman[26] has spotlighted the role of the auditory process in learning. He attributes the causative factor of reading difficulties primarily to lack of auditory discrimination. In the light of the developmental theory of auditory functioning discussed in the previous section of this chapter, however, it would appear that auditory discrimination is a prerequisite to attainment of normal development of auditory sequencing.

Another line of research views the problem from still another perspective and is concerned with sequencing as it relates to non-speech sounds. The studies by Tallal and Piercy[27], Muehl and Kremenak[28], Walters and Kosowski[29] and Wolf[30] use non-speech sounds to test the ability to maintain

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26 J. M. Wepman, "Auditory Discrimination, Speech and Reading", in Elementary School Journal, Vol. 60, No. 6, 1960, p. 325-333.

27 Paula Tallal and Malcolm Piercy, "Developmental Aphasia, Impaired Rate of Non-Verbal Processing as a Function of Sensory Modality", in Neuropsychologie, Vol. 11, No. 4, 1973, p. 389-398.

28 S. Muehl and S. Kremenak, "Ability to Match Information Within and Between Auditory and Visual Sense Modalities and Subsequent Reading Achievement", in Journal of Educational Psychology, Vol. 57, No. 4, 1966, p. 230-239.

29 Richard H. Walters and Irene Kosowski, "Symbolic Learning and Reading Retardation", in Journal of Consulting Psychology, Vol. 27, No. 1, 1963, p. 75-82.

30 C. W. Wolf, "An Experimental Investigation of Specific Language Disability (Dyslexia)", in Bulletin of the Orton Society, Vol. 17, No. 1, 1967, p. 32.

the structure of auditory stimuli and relate these findings to reading ability.

Tallal and Piercy[31] tested auditory sequencing of non-verbal stimulus materials on a control group of normal children and a group of aphasic children (children who had been diagnosed as having a severe language disorder) and found that the aphasic children had inferior discrimination and ordering skills. The total duration of stimulus patterns was found to be critical to the aphasic children's performance and the time available for processing auditory material was a critical factor in deficits of gross language disability. Tallal and Piercy concluded that children with aphasia were less able to hear and remember, or reproduce non-speech sounds, than were children with normal development.

Muehl and Kremenak[32] investigated the ability of first grade children to match a sequence of non-verbal information within and between auditory and visual sense modalities, and compared these results to subsequent reading achievement. Data were collected using dot and tone patterns. They found that between modality tasks (visual-auditory and auditory-visual) could be used to predict later reading achievement, but within

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31 Tallal and Piercy, <u>Op. Cit.</u>, p. 389-398.

32 Muehl and Kremenak, <u>Op. Cit.</u>, p. 230-239.

modality tasks (visual-visual and auditory-auditory) could not be used to predict later reading achievement. They suggested that:

> Preparatory to reading, the child must relate auditory patterns in speech, which are temporally ordered, to the spatially ordered visual patterns in print. To actually read, he must reverse the process of responding to the printed visual patterns with appropriate sound sequences.[33]

In simple terms, Muehl and Kremenak concluded that auditory sequencing was a necessary first step in reading.

To test children for auditory and visual perception of non-verbal material, Walters and Kosowski[34] compared poor readers in grades six, seven and eight with good readers in the same grades. The poor readers did as well as the advanced readers on visual-reaction-time tests using coloured lights: however, the poor readers did less well on auditory-reaction-time tests using pure tones. Because the poor readers improved when the incentive of a reward was offered and because practice improved performance, they concluded that retarded readers need more incentive. It has in fact been shown that poor readers are less attentive than good readers to stimuli, particularly auditory stimuli, so that a deficit in auditory sequencing continues to be reflected in poor reading skills at the grade six, seven and eight level.

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33 Muehl and Kremenak, Op. Cit., p. 230.

34 Walters and Kosowski, Op. Cit., p. 75-82.

In an investigation of specific language disability, Wolf[35] found the Seashore Measures of Musical Talents[36] was the best indicator for differentiating dyslexics from normals. He noted that four of the six areas, namely: rythmn, time, tonal memory and auditory blending, gave significant differences at a better than .01 probability level and that those four subtests all necessitated the sequencing of non-speech sounds. Therefore Wolf concluded that dyslexic children could most easily be identified through performance of tests which require sequencing of non-speech sounds.

In summary, the foregoing studies indicate that poor readers have a deficit in the ability to maintain the structure of an auditory perception, which appears to be separate from, or in addition to, sequencing of non-speech sounds.

Another field of thought examines a deficit in the structure of auditory stimuli in relation to language development including auditory sequencing. Based on their investigation of learning disabilities, Silver and Hagin[37] contend that the

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35 Wolf, Op. Cit., p. 32.

36 J. F. Jastak, S. W. Binjou and S. R. Jastak, "Wide Range Achievement Test - Reading, Spelling, Arithmetic from Pre-School to College", Wilmington, Guidance Associates, 1965.

37 Archie A. Silver and Rose A. Hagin, "Specific Reading Disability, An Approach to Diagnosis and Treatment", Readings for the Psychology of the Exceptional Child: Emphasis on Learning Disabilities, ed. Marvin Denburg, New York, MSS Information Corporation, 1974, p. 59-68.

basic component of learning disabilities is a disorientation in space and time. This disorientation is reflected in specific temporal and spatial distortions in the following sensory activities: 1) visual; 2) auditory; 3) tactile-kinesthetic; and 4) orientation of body image in space.

When children referred to Silver and Hagin's clinic are tested in these four areas, ninety percent of them exhibit problems in right-left orientation and visual perception while only fifty percent of them exhibit problems in auditory perception. Silver and Hagin suspect, however, that the incidence of children with auditory perceptual difficulties will be more evident with new improved testing techniques. Within the auditory area, the major difficulty lies in the sequencing of sounds, words and ideas. The children can comprehend the meaning, but the grasp of sounds in temporal sequence is distorted.

Along with an auditory sequencing problem coexists a difficulty in differentiating similarities and differences in auditory configurations, in blending and matching initial and final sounds, in repeating words in a sentence or putting sentences in a logical order. Children so afflicted have difficulty retaining or presenting ideas in a logical manner and in the later grades have comprehension and organization problems. It is relatively easy to establish a relationship between low scores on auditory sequencing tests and a child's inability to read causing learning problems which affect literally all of his schoolwork. It would appear, then, that Silver and Hagin view auditory sequencing as the most important reflection of auditory perceptual difficulties, which is a part of the learning disabled child's disorientation in space and time.

On the other hand, Luria[38] sees the main purpose of learning experiences in the child's life to be the acquisition of speech, necessitating sequencing of sound, and perceives the effective verbal communication between child and adult as a vital component to the transmission of knowledge and formation of concepts. His long-term research of a man who had lost some of his brain facility[39] reveals some of the highly intricate systems of signals of which language consists. Due to his brain dysfunctioning, "the man with a shattered world"[40] was unable to understand the logic implicit in grammatical construction and was only able to understand the syntax in which the word order fitted the sequence of actions.

Luria, thus, also sees auditory functioning as being inextricably tied up with speech and language, and he concludes

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38 A. R. Luria, The Mentally Retarded Child, translated by W. P. Robinson, London, Pergamon Press, 1963, p. 193-199.

39 A. R. Luria, The Man with a Shattered World, translated by Lynn Solotaroff, New York, Basic Books, 1972, p. 131.

40 *Ibid.*, p. x-160.

that serial order listening and the ability to re-auditorize develop simultaneously. Immaturity in this aspect of development is reflected in all aspects of the child's language development and in subsequent activities such as reading. Silver and Hagin[41] and Luria[42] would probably agree that the ability to maintain the structure of an auditory perception has an effect upon the child's language development which subsequently affects his ability to read.

There are other investigations which attribute reading difficulties to both auditory and visual modalities and purport to determine which of the two deficits is more responsible for reading failure. Four such studies follow.

Corkin[43] has recently attempted to ascertain whether or not sequencing ability has an effect on reading. She tested the hypothesis that reading disorders in children may in part grow out of a more general deficit in serial organization. A group of forty-eight boys (6 years 5 months to 11 years 9 months of age), one-half of whom were judged by their teachers to be inferior readers, were required to remember the correct serial

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41 Silver and Hagin, Op. Cit., p. 59-68.

42 Luria, Op. Cit., x-160 p.

43 Suzanne Corkin, "Serial-Ordering Deficits in Inferior Readers", in Neuropsychologie, Vol. 12, No. 3, 1974, p. 347-354.

position of visual and auditory stimuli. Ability to perform both tests increased markedly as function of age, but average readers surpassed inferior readers on tests of serial ordering at all ages studied. She concluded that reading disorders may stem from a more general deficit in serial organization that cuts across sensory modalities and stimulus materials.

To investigate the role of auditory, visual and intersensory abilities in reading, Zigmond[44] employed fifteen tests to appraise specific abilities of normal and dyslexic children: six auditory tests, four visual tests and five tests of intersensory functioning. Of the six auditory tests, five measured the ability to sequentialize and maintain the structure of an auditory perception by testing the: 1) memory for nonsense words; 2) memory for digits; 3) memory for words; 4) memory for sentences; and 5) memory for rythmic sequences. The sixth dealt with auditory discrimination and had particular relevance for the current research.

Zigmond's findings indicated that three of the four visual tests showed no significant difference between dyslexics and normals, while all five tests of intersensory functioning indicated that the dyslexics were inferior to the normal readers.

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44 Naomi Kershman Zigmond, "Auditory Processes in Children with Learning Disabilities", Learning Disabilities, Introduction to Educational and Medical Management, ed. Lester Tarnapol, Springfield, Charles C. Thomas, 1971, p. 208.

Of the fifteen tests given, the eleven tests in which there was at least one auditory component indicated lower scores for the dyslexics, while only one of the four visual measurement tests showed a difference between groups. Zigmond concluded that:

> The results suggest that the deficiencies in dyslexic children of this age may be specifically related to an auditory involvement rather than specifically to intersensory difficulties or to visual perceptual problems.[45]

Zigmond equated a deficit in auditory skills with a disability in reading and because five out of six of her tests measured auditory sequencing, it might be safe to say that she equated a deficit in the serial organization of auditory skills with a disability in reading.

A test which confirmed the serial-order hypothesis was conducted by Sanstedt[46]. Sandstedt measured auditory and visual memory span in a group of readers (8-13 years of age) performing below level and found that they did markedly better on visual memory span than on auditory memory span. An auditory sequencing deficit appeared to be the common element in the inability to read.

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45 Zigmond, Op. Cit., p. 208.

46 Barbara Sanstedt, "Relationship Between Memory Span and Intelligence of Severely Retarded Readers", in Reading Teachers, Vol. 17, No. 4, 1964, -. 246-250.

A very recent study conducted by Young[47] compared auditory sequencing to visual sequencing in children in grades two and six, half of whom were good readers and half of whom were poor readers. They were then matched for age and intelligence. He found that the poor readers in grade two did less well than the good readers on both visual and auditory tasks, but particularly on the auditory tasks. Young thus concluded that younger poor readers were less able to perform tasks of auditory sequencing and that this could be responsible for poor reading skills.

With reference to the studies just examined, if it is assumed that a serial order deficit is responsible for reading failure, then deficient auditory sequencing skills play a larger part in poor reading ability than visual sequencing skills.

Many other studies pertaining to sequencing have compared scores in the Wechsler Intelligence Scale for Children[48] to reading ability. From his experience as a clinical psychologist, Wechsler felt it necessary to look beyond composite scores to separate scores and chose digit span as a short-term

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47 Gerald C. Young, "A Comparison of Visual and Auditory Sequencing in Good and Poor Readers in Grades Two and Six", Unpublished manuscript, University of Windsor, Ontario, 1974, x-103 p.

48 D. Wechsler, "Wechsler Intelligence Scale for Children", New York, Psychological Corporation, 1949.

memory task, noting that a certain absolute minimum was essential for academic achievement.[49] Two other studies which place auditory skills above visual skills deal with the verbal portion of the WISC, which includes the test for auditory sequencing used in the current study.

In administering the WISC to a population of backward readers, Warrington[50] found relatively low verbal IQ to be by far the most common concommitant of reading and spelling backwardness. She felt that spatial difficulties as a cause of reading disorders were over-rated.

Belmont and Birch[51] gave the WISC to a group of nine and ten year old boys who were retarded in reading. Because the boys did poorly on the verbal scale of the WISC, the authors concluded that the reading problem resulted from an inadequacy in language functioning rather than from perceptual or manipulative inadequacies.

Lashley[52] is regarded as the pioneer in establishing

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49 Lee J. Cronbach, Essentials of Psychological Testing, New York, Harper and Row, 1949, p. 207.

50 Elizabeth K. Warrington, "The Incidence of Verbal Disability Associated with Retardation in Reading", in Neuropsychologie, Vol. 5, No. 2, 1967, p. 175-179.

51 L. Belmont and H. G. Birch, "The Intellectual Profile of Retarded Readers", in Perceptual and Motor Skills, Vol. 22, No. 6, p. 787-816.

52 K. Lashley, Cerebral Mechanisms in Behaviour, New York, John Wiley, 1951, p. 112-136.

cortical mechanism models for dealing with problems of temporal integrations. One of his findings that is relevant to the current research is that language skills such as writing, speaking, typing and reading are serially organized, so that items which come early in a sequence influence those that follow and vice versa.

The research paper which professed to build on the work of Lashley and deals specifically with the digit span subtest of the WISC was written by Rudel and Denckla.[53] Two hundred and ninety-seven subjects who had been diagnosed as children with learning disabilities were given the WISC. Examination of individual subtest scores showed that the WISC digit span scaled scores of these subjects fell well below any of their overall IQ scores and considerably below the expectation for the mean full scale, verbal or performance IQ of the group. Furthermore, more than thirty percent of the subjects had a discrepancy of three or more digits between their forward and backward digit spans, with the backward span naturally being lower.

Of these two hundred ninety-seven children, 292 subjects

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53 Rita G. Rudel and Martha B. Denckla, "Relation of Forward and Backward Digit Repetition to Neurological Impairment in Children with Learning Disabilities", in Neuropsychologie, Vol. 12, No. 1, 1974, p. 109-118.

had neurological data which allowed categorization according to their signs (presumed left-hemisphere damage, presumed right-hemisphere damage, presumed bilateral-hemisphere damage). Those with presumed left-hemisphere damage did less well on digits forward; subjects with presumed right hemisphere damage did less well on digits backward. Inability to repeat digits backward at all was usually demonstrated by those with bilateral impairment.

Rudel and Denckla[54] contended that the WISC digit span, which is treated as one sub-test, actually involves two separate and distinct entities. The recall of digits forward is an indication of maintenance of a given serial order in time; the recall of digits backwards involves a translation of the given serial order into left-right spatial coordinates and requires brief storage to read right to left.

Those who presumably had right-hemisphere damage showed large discrepancies between the number of digits forward and digits backward. The large gap between forward and backward digits tended to increase with age, since the ability to repeat digits forward increased without similar improvement in the ability to repeat them backwards.

On the other hand, those with presumed left-hemisphere

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54 Rudel and Denckla, Op. Cit., p. 109-118.

damage tended to increase their ability to repeat digits backward to the point of even equalling forward repetition. Their findings supported previous studies which claim that the left brain hemisphere is primarily responsible for the auditory-verbal functioning and the right for visual-spatial functioning.

Rudel and Denckla concluded that children with learning disabilities have a short-term memory defect, which is apparent in immediate recall of temporal sequences and even more apparent when this sequence must be reversed. If it is true that backward recall involves changing a temporal sequence to a task of spatial coordinates, it might be expected that those children who have much difficulty will have trouble with arithmetic and tasks which require matching of serial and spatial orders. Rudel and Denckla stated that:

> Much of the literature demonstrating deficits in cross-modal matching or 'intersensory integration' in children with learning disabilities can be explained in terms of difficulties with temporal-spatial or spatial-temporal matching without reference to differences in modality.[55]

The above findings deal with the WISC digit span in relation to reading ability. Warrington[56] and Belmont and Birch[57] contended that reading deficits resulted from deficits

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55 Rudel and Denckla, Op. Cit., p. 114.

56 Warrington, Op. Cit., p. 175-179.

57 Belmont and Birch, Op. Cit., p. 787-816.

in the language and auditory functioning. Rudel and Denckla[58] proposed that learning disabilities could be explained in terms of a child's ability to maintain the temporal sequence of digits in mind long enough to read them forwards or backwards.

The authors of each of these three studies found that a low verbal score on the WISC (and particularly on digit span) is a good prediction of reading difficulty, and that the auditory sequencing skills shown to be deficient are a probable cause of poor reading. In summary, a synthesis of findings relating to auditory sequencing emphasizes the link with reading skills.

Impairments to normal development of auditory functioning cause difficulty generating principles for sentence structure and remembering sequences of auditory perceptions. An investigation of theories of communication indicates that auditory sequencing is an automatic process which deals with the auditory channel and is one of the processes of sequential memory (Kirk, McCarthy and Kirk).[59] Poor auditory sequencing results from a deficit in psychological language and in the central nervous system involving the auditory channel and causes problems at the perceptual and imagery level of the learning process (Johnson

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58 Rudel and Denckla, Op. Cit., p. 325-333.

59 Samuel A. Kirk and Winifred D. Kirk, Psycholinguistic Learning Disabilities, Diagnosis and Remediation, Chicago, University of Illinois Press, 1971, x-159 p.

and Myklebust).[60]

The literature reveals a trend toward the acceptance of an auditory sequencing deficit as one of the causative factors of reading difficulties. While such difficulties have been attributed to deficits in both auditory and visual sequencing, a comparison of non-speech and non-symbolic sequences indicates that even at this non-speech level a deficiency in auditory sequencing is more closely related to reading difficulties than a deficiency in visual sequencing.

The literature has also revealed that the ability to maintain the structure of an auditory perception has an effect upon a child's language development and hence his communication skills which include reading.

Another concept which permeates the literature dealing with auditory sequencing is that the verbal subtest scores of the WISC (and particularly digit span) are highly related to reading ability scores.

The purpose of the current research is to determine whether the inability to sequence at the most basic level (a deficit in auditory sequencing) is common to all children who have been placed in junior classes for children with learning disabilities, regardless of their specific diagnosis of visual,

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60 Doris J. Johnson and Helmer R. Myklebust, Learning Disabilities, Educational Principles and Practices, New York, Grune and Stratton, 1967, x-336 p.

auditory, tactile or kinesthetic deficits. The theory holds that in reading the child must be able to sequence in the correct direction, and retain the image in mind as he imposes the auditory process on the visualized sequence. The mediation process involved in retaining the structure of the repeated digits in order to repeat them backwards is akin to the reading process.

This reasoning is translated into the following research hypothesis:

> Children in learning disability classes who have attained relatively low reading scores will have relatively low scores on tests of auditory sequencing: conversely, those who have attained relatively high reading scores will have relatively high scores on tests of auditory sequencing.

CHAPTER II

EXPERIMENTAL DESIGN

This chapter is composed of four parts, namely: the sample, measuring instruments, testing procedure and the data analysis plan.

1. Sample

The sample population consisted of fifty-nine boys between the ages of 8 years 2 months and 12 years 9 months who had been placed in classes for children with learning disabilities within the Carleton Public School Board of Ontario.

Children with learning disabilities are those who have adequate mental or intellectual ability, whose sensory processes are intact, whose emotional stability is within the normal range, but who experience deficits in their receptive, integrative and expressive processes. Extensive testing is normally carried out prior to placement in learning disability classes to determine whether lack of school achievement is due to some type of learning disability as opposed to low global intelligence, physical handicap or primary emotional disorder.

For the current research, the group tested was homogeneous in that they were all performing at a reading level considerably below that of their peers, or that expected of a child with normal or above average intelligence. In order to eliminate as many variables as possible, and because there are very few girls in learning disability classes, only boys were chosen for the sample.

No other selection bias was used.

2. Measuring Instruments

The hypothesis suggests that children in learning disability classes who have attained higher reading scores will also score higher on tests of auditory sequencing. In order to provide some basis for normalization of scores, the age in months was recorded for each child at the time of testing.

Each child had been given the Wechsler Intelligence Scale for Children (WISC)[1] prior to placement in special classes, so the most recent score was used for each child. These Full Scale WISC scores were obtained from Special Services of the Carleton Public School Board.

To compare sequencing scores to reading scores, two measures of reading ability were obtained.

1) The teacher assessment of the child's ability to read was chosen because a teacher in daily contact with a child is able to assess his level of functioning over a longer period of time. Because the testing was done near the end of the school term, all

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1 D. Wechsler, "Wechsler Intelligence Scale for Children", New York, Psychological Corporation, 1949.

teachers had approximately eight months to determine the reading level of the small group of students in their classrooms. In addition, at the request of Carleton's Special Services, all teachers had completed some form of standardized testing for end of year reports. One of the attributes of children in learning disability classes appears to be impulsiveness and inconsistency in moods and work habits from day to day. The choice of a teacher assessment score is an attempt to avoid the high-low peaks of any one testing situation on any one particular day. The reliability of the teacher's assessment is demonstrated in the close correlation (.83) to the standardized reading test score of each child.

The teacher was asked to assess the child's ability when he was reading aloud to her on an individual basis.

2) The word recognition subtest of the Wide Range Achievement Test (WRAT)[2] was chosen to gain an objective assessment of the child's ability to read words at sight. The test begins with naming letters at the pre-reading level and progresses to an adult reading level. Reliability coefficients of .95 were determined by repeated testing of reading.[3]

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2 J. F. Jastak, S. W. Binjou and S. R. Jastak, "Wide Range Achievement Test - Reading, Spelling, Arithmetic from Pre-School to College", Wilmington, Guidance Associates, 1965.

3 Louis P. Thorpe, "Wide Range Achievement Test", The Third Mental Measurements Yearbook, Highland Park, Gryphon Press, 1949, p. 22.

In order to test the child's ability to sequentialize and maintain the structure of an auditory perception subtests from the full scale WISC and from the Detroit Tests of Learning Aptitude[4] were chosen.

1) The Wechsler Intelligence Scale for Children Digit Span subtest (forward and backward) was chosen as a test of auditory sequencing because:

a. of its demonstrated association with reading ability. As mentioned previously, studies by Warrington[5], Belmont and Birch[6] indicated that children with low reading ability also scored low on verbal scores of the WISC. Rudel and Denckla[7] also showed that the forward and backward digit span subtest scaled scores of the WISC were notably low for children with learning disabilities.

b. it involves only the auditory input and vocal output channels

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4 J. Baker and B. Leland, Detroit Tests of Learning Aptitude, Indianapolis, Bobbs-Merrill, 1959.

5 Elizabeth K. Warrington, "The Incidence of Verbal Disability Associated with Retardation in Reading" in Neuropsychologie, Vol. 5, No. 2, 1967, p. 175-179.

6 L. Belmont and H. G. Birch, "The Intellectual Profile of Retarded Readers", in Perceptual and Motor Skills, Vol 22, No. 6, 1966, p. 787-816.

7 Rita G. Rudel and Martha B. Denckla, "Relation of Forward and Backward Digit Repetition to Neurological Impairment in Children with Learning Disabilities", in Neuropsychologie, Vol. 12, No. 1, 1974, p. 109-118.

of communication. The WISC digit span is designed to test the ability of a child to listen to a series of numbers and repeat them in the same order in digits forward and in reverse order in digits backward. The reliability (the extent to which the test is consistent in measuring this ability) given for digit span in the manual is based on test-retest or stability coefficients; at age 10½ the reliability is .71 and at age 11½ it is .75.[8] It demonstrates the ability of the test to distinguish between persons who are able to sequentialize and maintain the structure of an auditory perception and those who cannot.

The digits forward subtest verifies a child's ability to repeat a series of numbers in the order given by the examiner, beginning with three numbers. The number of digits repeated is increased until two tests of the same number of digits are failed.

The digits backward subtest tests the ability of a child to repeat digits in reverse order, the simplest trial being the juxtaposition of two numbers, and the most difficult being the juxtaposition of eight numbers.

2) The Detroit Tests of Learning Aptitude was chosen:

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8 D. Wechsler, "Wechsler Intelligence Scale for Children Manual", 1949, New York, Psychological Corporation, 1949, p. 3.

a. because of its demonstrated usefulness in differentiating children with learning difficulties;[9]

b. because, "for its dimensions there has never been so useful a procedure in clinical psychometrics";[10] and

c. because it tests more than one dimension of the child's ability to hear and maintain an auditory perception, namely: the ability to sequentialize unrelated words, words in sentences and to follow a series of oral directions.

The reliability of the Detroit Tests of Learning Aptitude was tested on a group of 792 pupils ranging in age from seven to twelve. A correlation of $.675 \pm 1$ was found.[11] The three subtests chosen from the Detroit Tests of Learning Aptitude for the current research were the "Auditory Attention Span for Unrelated Syllables", the "Auditory Attention Span for Related Syllables" and the "Oral Commissions" subtests.

The Auditory Attention Span for Unrelated Syllables tests a child's ability to hear and maintain the structure of unrelated one-syllable words long enough to repeat them, beginning with two words and progressing to eight words in the series.

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9 Naomi Kershman Zigmond, "Auditory Processes in Children with Learning Disabilities", Learning Disabilities, Introduction to Educational and Medical Management, ed. Lester Tarnapol, Springfield, Charles C. Thomas, 1971, p. 208.

10 F. L. Wells, "Detroit Tests of Learning Aptitude", The Third Mental Measurements Yearbook, ed. O. K. Buros, Highland Park, Gryphon Press, 1949, p. 275.

11 Ibid., p. 275.

The Auditory Attention Span for Related Syllables tests a child's ability to repeat a series of sentences which range from five words of 6 syllables to twenty-two words with 27 syllables.

The Oral Commissions subtest examines the ability of a child to follow a series of directions proceeding from one to four consecutive directions.

3. Collection and Description of the Data

All testing was done in a school area provided by the school staff, and varied from unoccupied libraries to supply rooms. In all instances, a three-sided cardboard booth (36 inches high and 3 panels each 25 inches wide) was placed on a desk directly in front of and to the sides of the examiner and the subject. The examiner's chair was placed to the left of the subject's chair. No visual distractions except the testing material were in the immediate area (as illustrated in Appendix 3).

Each subject received all six tests. Each testing situation began with a different test in order to control for the effects of practice and fatigue. The six tests were given in consecutive order beginning for each new child with one test further down the list. For example, if the first child began at test two, the second child tested began at test number three, the third child at test four and so on in order to eliminate order of testing bias.

The testing was conducted by researchers who had been through a period of training and initial testing procedures were supervised by the investigator. Each test inclduing repetition of digits, words and sentences, had been pre-recorded on tape in order to standardize conditions as much as possible for all subjects.

All testing was done during school hours. Each subject was brought to the testing area and asked to sit on the chair in front of the three-sided cardboard booth. After a brief discussion to make the subject feel at ease, the tests were begun.

4. Data Analysis Plan

The total sample involved in the current study comprised fifty-nine subjects. There are three independent variables: 1) Wide Range Achievement Test Word Recognition; 2) Teacher Assessment of Reading Ability; and 3) Average Reading Score of the WRAT and the Teacher Assessment; and four dependent variables: 1) Digit Span (Wechsler Intelligence Scale for Children Digit Span Subtest); 2) Words (Auditory Attention Span for Unrelated Syllables); 3) Sentences (Auditory Attention Span for Related Syllables); and 4) Directions (Oral Commissions which requires the child to follow a series of directions).

The means of Digit Span, Words, Sentences and Directions is presented for both relatively poor and relatively good readers with each of the independent variables (reading scores). To determine the relative dispersion of scores for each of the dependent variables, again as a basis for comparison, standard deviations within subtests are included. To determine how statistically different the sequencing scores of the relatively poor readers are from the relatively good readers, a multi-variate analysis of variance has been carried out and is presented in Tables I, II and III.

Each of the three independent variables is divided into two extremes, namely: the lowest fifteen reading scores and the highest fifteen reading scores with the middle scores being deleted in order to obtain two separate and distinct groups.

The plan of the analysis was as follows:

1) To carry out a multi-variate analysis of variance on the four sequencing scores with performance scores on Teacher Assessment, WRAT Reading Recognition and Average Reading Score of the two combined as independent variables.

2) To do a correlation to find which of the dependent variables explained more of the variance between the scores of the relatively good readers.

The data were analyzed using the Full Rank Approach, which yields all the multi-variate significance test statistics, such as Roy's Criterion, Bartlett's Test for Significant

Discriminant Function, the Lawley-Hotelling Trace Criterion and a Multi-variate-F for the purposes of the present research. The .05 level of significance was accepted throughout.

The original objective was to show that all children in learning disability classes have some deficit in auditory sequencing.

The purpose of this chapter was to present the design of the study. A description of the subjects was given followed by a description of the instruments used, with evidence presented concerning their validity and reliability. The testing situation, the order of presentation of tests and the testing procedures used were described. The chapter concluded with the plan of the analysis. The statistical results are presented in the next chapter.

CHAPTER III

PRESENTATION OF RESULTS

This chapter presents the results of the analysis derived from the raw data scores found at Appendix I. Table I presents the Mean Score and the Standard Deviation from the Mean of the fifteen lowest reading scores in the reading group as measured by the WRAT, and the Mean and Standard Deviation of the fifteen highest scores in the reading group (WRAT). Roy's Criterion indicates statistically the difference between the two groups. The Critical Value gives the value necessary to show significance at the .05 level.

The results shown in Table I indicate that the auditory sequencing scores of relatively poor readers are significantly different at the .05 level from auditory sequencing scores of relatively good readers.

Similarly, the results shown in Table II indicate that the auditory sequencing scores of relatively poor readers, as measured by Teacher Assessment, are also significantly different at the .05 level from the auditory sequencing scores of relatively good readers as measured by Teacher Assessment.

As expected, the results shown in Table III indicate that the auditory sequencing of relatively poor readers, as measured by the average reading score, is significantly different at the .05 level from the auditory sequencing scores of relatively good readers as measured by the average reading score.

Table I.-

Multi-variate Analysis of Variance Using Roy's Criterion for Testing Differences between Auditory Sequencing Scores of Relatively Poor Readers (WRAT) and Relatively Good Readers (WRAT)

	Cell 1 Lows		Cell 2 Highs			
Sequencing	Mean	SD	Mean	SD	Roy's Criterion	Critical Value
Digit Span	81.7	16.3	116.4	30.0	.41*	.69
Words	61.2	20.8	86.7	34.7		
Sentences	63.1	21.0	72.3	27.8		
Directions	89.6	6.4	92.4	6.5		

First - value is S = 1, Second M = 1 and Third N = 11.5.
*Significance is at the .05 level.

Cell 1 refers to those fifteen poor readers who scored lowest on the test of WRAT Word Recognition.
Cell 2 refers to those fifteen poor readers who scored highest on the test of WRAT Word Recognition.
Digit Span - Digit Span subtest of the Wechsler Intelligence Scale for Children
Words - Ability to Sequence Unrelated Syllables
Sentences - Ability to Sequence Related Syllables
Directions - Ability to Follow Sequences of Directions (Oral Commissions)

Table II.-

Multi-variate Analysis of Variance Using Roy's Criterion for Testing Differences between Auditory Sequencing Scores of Relatively Poor Readers (Teacher Assessment) and Relatively Good Readers (Teacher Assessment)

	Cell 1 Lows		Cell 2 Highs			
Sequencing	Mean	SD	Mean	SD	Roy's Criterion	Critical Value
Digit Span	83.3	16.5	108.9	33.9	.23*	.69
Words	62.1	18.0	76.6	38.8		
Sentences	65.1	20.5	68.3	32.7		
Directions	89.6	6.4	92.4	6.4		

First - value is S = 1, Second M = 1 and Third N = 11.5.
*Significance is at the .05 level.

Cell 1 refers to those fifteen poor readers who scored lowest on the Teacher Assessment.
Cell 2 refers to those fifteen poor readers who scored highest on the Teacher Assessment.
Digit Span - Digit Span Subtest of the WISC
Words - Ability to Sequence Unrelated Syllables
Sentences - Ability to Sequence Related Syllables
Directions - Ability to Follow Sequences of Directions (Oral Commissions)

Table III.-

Multi-variate Analysis of Variance Using Roy's Criterion for Testing Differences between Auditory Sequencing Scores of Relatively Poor Readers (Average Reading Score) and Relatively Good Readers (Average Reading Score)

	Cell 1 Lows		Cell 2 Highs			
Sequencing	Mean	SD	Mean	SD	Roy's Criterion	Critical Value
Digit Span	83.9	16.2	111.9	32.1	.31*	.69
Words	62.1	18.0	82.7	35.8		
Sentences	65.0	20.7	71.6	29.0		
Directions	90.0	6.0	93.1	6.7		

First - value is S = 1, Second M = 1 and Third N = 11.5.
*Significance is at the .05 level.

Cell 1 refers to those fifteen poor readers who scored lowest on the Average Reading Score of the WRAT and Teacher Assessment.
Cell 2 refers to those fifteen poor readers who scored highest on the Average Reading Score.
Digit Span - Digit Span Subtest of the WISC
Words - Ability to Sequence Unrelated Syllables
Sentences - Ability to Sequence Related Syllables
Directions - Ability to Follow Sequences of Directions (Oral Commissions)

To find which of the dependent variables (digit span, words, sentences or directions) was most responsible for the variance between the scores of poor readers having relatively low reading scores, a correlation of original or transformed variate with discriminant function was done.

The results shown in Table IV indicate that digit span explains more of the observed variance between the scores of relatively poor readers and relatively good readers (WRAT reading assessment). A simple rank order shows that words explain the next amount of observed variance, followed by directions and finally sentences.

The simple rank order shown in Table V indicates that again digit span explains more of the observed variance between the scores of relatively poor readers and relatively good readers (teacher assessment) followed by words, directions and sentences in that descending order.

The correlation of original or transformed variate with discriminant function in Table VI once again reveals digit span as explaining more of the observed variance between the scores of relatively poor and relatively good readers (average reading score) than words, directions or sentences.

Table IV

Correlation of Original or Transformed Variate with Discriminant Function Using Auditory Sequencing Scores of Relatively Poor Readers (WRAT) and Relatively Good Readers (WRAT)

Sequencing	Correlation with Discrimination	Percentage
Digit Span	.877	88%
Words	.550	55%
Sentences	.233	23%
Directions	.269	27%

Digit Span - Digit Span Subtest of the WISC
Words - Ability to Sequence Unrelated Syllables
Sentences - Ability to Sequence Related Syllables
Directions - Ability to Follow Sequences of Directions (Oral Commissions)

Table V.-

Correlation of Original or Transformed Variate with Discriminant Function Using Auditory Sequencing Scores of Relatively Poor Readers (Teacher Assessment) and Relatively Good Readers (Teacher Assessment)

Sequencing	Correlation with Discrimination	Percentage
Digit Span	.914	91%
Words	.459	46%
Sentences	.307	31%
Directions	.415	41%

Digit Span - Digit Span Subtest of the WISC
Words - Ability to Sequence Unrelated Syllables
Sentences - Ability to Sequence Related Syllables
Directions - Ability to Follow Sequences of Directions (Oral Commissions)

Table VI.–

Correlation of Original or Transformed Variate with Discriminant Function Using Auditory Sequencing Scores of Relatively Poor Readers (Average Reading Score) and Relatively Good Readers (Average Reading Score)

Sequencing	Correlation with Discrimination	Percentage
Digit Span	.845	85%
Words	.560	56%
Sentences	.203	20%
Directions	.365	37%

Digit Span - Digit Span Subtest of the WISC
Words - Ability to Sequence Unrelated Syllables
Sentences - Ability to Sequence Related Syllables
Directions - Ability to Follow Sequences of Directions (Oral Commissions)

This chapter presented the results of the analysis. The raw data are presented as Appendix I.

CHAPTER IV

DISCUSSION OF THE RESULTS

The results detailed in the previous chapter may now be related directly to the research findings cited in Chapter one.

It will be recalled that in Chapter one an auditory sequencing facility was found to be one of the prerequisites of normal development of communication skills. To equate a deficit in auditory sequencing with disabilities in learning, various aspects of two theoretical constructs were explored. Kirk, McCarthy and Kirk's work on the ITPA (as outlined by Kirk and Kirk)[1] showed that auditory sequencing is one of the automatic processes utilizing the auditory channel, and is one of the processes of receptive sequential memory. Johnson and Myklebust's work[2] indicated that auditory sequencing involves both psychological and central nervous systems and is an intra-neurosensory type of learning involving primarily the perceptual level of learning.

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1 Samuel A. Kirk and Winifred D. Kirk, Psycholinguistic Learning Disabilities, Diagnosis and Remediation, University of Illinois Press, Chicago, 1971, p. 19-23.

2 Doris J. Johnson and Helmer R. Myklebust, Learning Disabilities: Educational Principles and Practices, New York, Grune and Stratton, 1969, x-336 p.

In the work of Luria[3] it was claimed that the inability to hear and re-auditorize speech sounds causes inadequate language development and subsequent learning problems. Silver and Hagin[4] view a deficit in auditory sequencing as one component of a total disorientation in space and time: it is this disorientation which causes difficulties in retaining and presenting ideas in a logical order, which is reflected in poor reading ability. In their view auditory sequencing appears to be directly related to language development and communication skills which include reading.

Auditory sequencing then, is placed at the most basic automatic level of functioning directly influencing the communication skills such as reading which come later in the total development. The rationale for the hypothesis of the current research was that children who are poor at auditory sequencing would be poor readers. If this were true, then poor readers who obtained lower reading scores would also score lower on tests of auditory sequencing.

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3 A. R. Luria, The Mentally Retarded Child, translated by W. P. Robinson, London, Pergamon Press, 1963, p. 193-199.

4 Archie A. Silver and Rose A. Hagin, "Specific Reading Disability, An Approach to Diagnosis and Treatment", Readings for the Psychology of the Exceptional Child: Emphasis on Learning Disabilities, New York, MSS Information Corporation, 1974, p. 59-68.

Accordingly, it was hypothesized that:

> Children in learning disability classes who have attained relatively low reading scores will have relatively low scores on tests of auditory sequencing: conversely, those who have attained relatively high reading scores will have relatively high scores on tests of auditory sequencing.

To determine the statistical difference between sequencing scores of the relatively poor readers and the relatively good readers, a multi-variate analysis of variance was carried out and the results presented in the previous chapter.

Tables I, II and III present the results of a multivariate analysis of variance to discriminate between auditory sequencing scores of two extreme groups, namely: 1. those poor readers who have relatively high reading scores; and 2. those poor readers who have relatively low reading scores as measured by the three independant variables (WRAT, teacher assessment and average combined score). This test of the hypothesis showed that those poor readers who scored lowest on tests of reading ability obtained significantly lower sequencing scores than those poor readers who scored highest on tests of reading ability. In other words, a distinct correlation appears to exist between the ability to hear and repeat temporally ordered patterns of speech, and the ability to read.

The current research thus tends to support the studies cited in Chapter I which claim that there is a relationship between deficient sequencing skills and low reading ability.

It will be recalled that investigations of sequencing, as it relates to non-speech sounds, conducted by Tallal and Piercy[5], Muehl and Kremenak[6], Walters and Kosowski[7] and Wolf[8] indicated that the ability to maintain the structure of an auditory perception was directly related to reading ability even if speech sounds were not used.

Tallal and Piercy[9] indicated that children with a severe communication disorder were less able to hear and remember or reproduce non-speech sounds than were children with normal development, while Muehl and Kremenak[10] decided that auditory sequencing was a necessary first step in reading.

A test of non-verbal sequencing performed by Walters

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5 Paula Tallal and Malcolm Piercy, "Developmental Aphasia, Impaired Rate of Non-Verbal Processing as a Function of Sensory Modality", in Neuropsychologie, Vol. 11, No. 4, 1973, p. 389-398.

6 S. Muehl and S. Kremenak, "Ability to Match Information Within and Between Auditory and Visual Modalities and Subsequent Reading Achievement", in Journal of Educational Psychology, Vol. 57, No. 4, 1966, p. 230-239.

7 Richard H. Walters and Irene Kosowski, "Symbolic Learning and Reading Retardation", in Journal of Consulting Psychology, Vol. 27, No. 1, 1963, p. 75-82.

8 C. W. Wolf, "An Experimental Investigation of Specific Language Disability (Dyslexia)", Bulletin of the Orton Society, Vol. 17, No. 1, p. 32.

9 Tallal and Piercy, Op. Cit., p. 389-398.

10 Muehl and Kremenak, Op. Cit., p. 230-239.

and Kosowski[11] confirmed a relationship between poor readers and poor scores on auditory sequencing tests at grade six, seven and eight levels. The current research tends to support the contention of Walters and Kosowski that deficient auditory sequencing skills continue to be deficient in the child who has trouble with reading beyond the first few years of school, when a developmental lag might more readily be given as the cause of deficient sequencing skills. Even at grades six to eight, where the ages of pupils lie within the age criterion of the current study, auditory sequencing skills are lower for poor readers than for good readers.

As noted in part I, Wolf[12] used the Seashore Measures of Musical Talents to determine that dyslexic children could best be identified through performance on tests which involved auditory sequencing. Because the current research uses only tests of auditory sequencing and finds a direct relationship between sequencing and reading skills, it tends to support Wolf's study and all four studies which claim that poor readers have a deficit in the ability to maintain the structure of an auditory perception.

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11 Walters and Kosowski, Op. Cit., p. 75-82.

12 Wolf, Op. Cit., p. 32.

A second part of the research findings were concerned with the role of auditory sequencing versus visual sequencing as it related to reading. Studies by Corkin[13], Zigmond[14], Sanstedt[15] and Young[16] found that auditory sequencing appeared to be a more important fact in reading ability than did visual sequencing.

Although a comparison of the two modalities was not conducted in the current research the fact that children are placed in learning disabled classes for a wide variety of reasons, yet exhibit auditory sequencing skills well below those of children in the regular classroom, supports the contention that auditory skills are an important facet of the reading problem. A more detailed discussion of these studies follows in the light of subsequent statistical analysis.

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13 Suzanne Corkin, "Serial Ordering Deficits in Inferior Readers", in Neuropsycholgie,Vol. 12, No. 3, 1974, p. 347-354.

14 Naomi Kershman Zigmond, "Auditory Processes in Children with Learning Disabilities", Learning Disabilities, Introduction to Educational and Medical Management, ed. Lester Tarnapol, Springfield, Charles C. Thomas, p. 196-312.

15 Barbara Sanstedt, "Relationship Between Memory Span and Intelligence of Severly Retarded Readers", in Reading Teachers, Vol. 17, No. 4, 1964, p. 246-250.

16 Gerald C. Young, "A Comparison of Visual and Auditory Sequencing in Good and Poor Readers in Grades Two and Six", Unpublished Doctoral thesis presented to the Faculty of Education at the University of Windsor, Ontario, 1974, 123 p.

In order to determine whether a .05 level of significance existed between sequencing scores and reading ability as measured by the three independent variables, the data were analyzed using the Full Rank Approach yielding all the multivariate significance test statistics such as Roy's Criterion.[17] Further examination of the results indicates that while all three independant variables show a significant level of difference between sequencing scores of lower and higher readers, the WRAT word recognition score shos a higher correlation to reading ability than does the teacher assessment or combined average score.

In other words, the results of the multi-variate analysis of variance indicate that auditory sequencing ability is more closely related to the WRAT word recognition score than the teacher assessment of reading ability or the average reading score of the two combined. This suggests that an auditory deficit seems to be more evident when a child has to impose the auditory sequence on isolated symbols such as words rather than when other factors such as context clues are included. The word recognition test is an indication of the child's ability to retain the series of sounds long enough to reproduce a word, which appears to be an indication of strength or weakness at the most basic

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17 F. J. Wall, The Generalized Variance Ratio U-Statistics, Albuquerque, The Dikewood Corporation, 1967, p. 490.

level of sequencing of sounds. Deficient sequencing skills result in deficient communication skills. Hard expressed it this way:

> It seems entirely resonable that this is what is involved in much of dyslexia (...) an inadequacy in the reinforcing mechanisms which make process, pattern formation and retention possible and productive.[18]

As previously mentioned, several studies discussed in Chapter I investigated the role of auditory versus visual sequencing skills. In testing the hypothesis that reading disorders may grow out of a more general deficit in serial organization, Corkin[19] found that average readers surpassed inferior readers on tests of serial ordering at all ages studied. Zigmond commented that:

> The results suggest that the deficiencies in dyslexic children of this age may be specifically related to an auditory involvement rather than specifically to intersensory difficulties or to visual perceptual problems.[20]

Sanstedt[21] found that an auditory sequencing deficit appeared to be the common element in the inability to read,

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18 William G. Hard, "Dyslexia in Relation to Diagnostic Methodology in Hearing and Speech Disorders", Reading Disability, ed. John Money, Baltimore, John Hopkins Press, 1966, p. 175.

19 Corkin, Op. Cit., p. 347-354.

20 Zigmond, Op. Cit., p. 208.

21 Sanstedt, Op. Cit., p. 246.

while Young[22] concluded that younger poor readers were less able to perform tasks of auditory sequencing than good readers and that this could be responsible for poor reading skills. The current research tends to support and verify all of these serial order studies.

If a child shows a closer connection between auditory sequencing and word recognition than between auditory sequencing and general reading ability, other factors such as visual context clues could account for the difference. In finding that this relationship did in fact obtain, the current research appears to support those authors who attribute reading problems primarily to deficiencies in auditory serial ordering.

The second part of the analysis involved a correlation to find which of the dependent variables explained more of the variance between the scores of the relatively poor and the relatively good readers. Tables IV, V and VI showing the correlation of original or transformed variate with discriminant function, indicate that digit span explains more of the observed variance between low and high readers than words (which is second), directions (which is third), or sentences (which explains the least variance).

The fact that those tests which are more purely tests of auditory sequencing, namely digit span and words, explain more of the variance between low and high reading scores than

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22 Young, Op. Cit., p. 39.

repetition of sentences or directions, tends to support the studies mentioned earlier in this discussion by Tallal and Piercy[23], Muehl and Kremenak[24], Walters and Kosowski[25] and Wolf[26]. Other studies contend that poor readers have a deficit in the ability to maintain the structure of an auditory perception which appears to be separate from and in addition to the sequencing of non-speech sounds. Those tests which have fewer extraneous influences show most correlation with reading.

During the past several years there have been many studies which compared subtest scores of the WISC to reading ability. Warrington[27], Belmont and Birch[28] and Rudel and Denckla[29]

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23 Tallal and Piercy, Op. Cit., p. 389-398.

24 Muehl and Kremenak, Op. Cit., p. 230-239.

25 Walters and Kosowski, Op. Cit., p. 75-82.

26 Wolf, Op. Cit., p. 32.

27 Elizabeth K. Warrington, "The Incidence of Verbal Disability Associated with Retardation in Reading", in Neuropsychologie, Vol. 5, No. 2, 1967, p. 175-179.

28 L. Belmont and H. G. Birch, "The Intellectual Profile of Retarded Readers", in Perceptual and Motor Skills, Vol. 22, No. 6, 1966, p. 787-816.

29 Rita G. Rudel and Martha B. Denckla, "Relation of Forward and Backward Digit Repetition to Neurological Impairment in Children with Learning Disabilities", in Neuropsychologie, Vol. 12, No. 1, 1974, p. 109-118.

all concluded that the verbal scores on the WISC (and particularly digit span) were highly related to reading ability.

It will be recalled that Warrington[30] attributed reading and spelling backwardness to verbal deficiencies and felt that spatial difficulties as a cause of reading problems were over-rated. Similarly, Belmont and Birch[31] concluded that reading problems resulted from an inadequacy in language as opposed to perceptual functioning.

The research done by Rudel and Denckla[32] appears to have particular relevance for those interested in learning disabilities. Their conclusion that children with learning disabilities have a short-term memory defect, which is apparent in immediate recall of temporal sequences, and even more apparent when this sequence must be reversed, is supported by the current research. Rudel and Denckla placed particular emphasis on the ability of children with learning disabilities to recall digits forward or backward, indicating that the WISC digit span is a simple screening device to determine the need for further testing. Because digit span explained more of

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30 Warrington, Op. Cit., p. 175-179.

31 Belmont and Birch, Op. Cit., p. 787-816.

32 Rudel and Denckla, Op. Cit., p. 109-118.

the variance between the scores of the relatively poor and the relatively good readers, the current research supports the conclusions of Rudel and Denckla.

The task which accounted for the next level of observed variance between scores is the repetition of unrelated words, the task most similar to digit span. The fact that in order to repeat unrelated words, unrelated images must be held in mind reinforces the suggestion that difficulties in reading may result from the inability to sound out symbols in proper sequential order. Even if a child can master the phono-visual phonic sounds, total skills necessary for reading necessitate sequencing of sounds.

In the light of past research findings and the results of the current research, it is reasonable to support the comments made by Muehl and Kremenak to explain how auditory sequencing plays a part in the reading process:

> Preparatory to reading, the child must relate auditory patterns in speech, which are temporally ordered, to the spatially ordered visual patterns in print. To actually read, he must reverse the process of responding to the printed visual patterns with appropriate sound sequences.[33]

Thus if a child is unable to hold the auditory structure in mind long enough to repeat digits backwards, he may well

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33 Muehl and Kremenak, *Op. Cit.*, p. 230.

have trouble holding the visual spatial structure of printed words in mind long enough to impose an auditory temporal sequence. Soúnding out a word involves holding the visual image in mind while imposing the auditory process in correct sequential order.

The fact that auditory sequencing scores are more closely related to the word recognition score, and that digit span explains more of the variance between low and high scores, indicates that:

1. when a child is asked to read an unfamiliar work, it is the retention of the temporal order of syllables which determines his ability or inability to grasp that word. He may be able to recall the word visually if asked to reproduce it in written form, yet be unable to recall the series of sounds which make up that word; thus word recognition appears to be a task of imposing an auditory sequence onto a visual clue and retaining that sequence to grasp the total word.

2. the ability to name three digits forward might be considered a good indication of the child's ability to hear and repeat a three syllable word. The ability to name digits backward may well be an indication of his ability to visualize a word in spatial terms long enough to impose auditory symbols and express it verbally; thus low digit span scores are closely related to the inability to retain the auditory structure required to sound out a word.

The child who cannot sequence at the most basic level of immediate recall of digits also has low scores on tasks which require more advanced skills such as those required to read. It is the contention of the current research that it is the ability or inability to reproduce the necessary sequence of sounds which determines in large part the child's ability to read.

SUMMARY AND CONCLUSIONS

In attempting to provide an empirical test of auditory sequencing ability for children placed in learning disability classes, the following hypothesis was proposed:

> Children in learning disability classes who have attained relatively low reading scores will have relatively low scores on tests of auditory sequencing: conversely, those who have attained relatively high reading scores will have relatively high scores on tests of auditory sequencing.

In an attempt to validate this hypothesis, the reading scores (obtained from a teacher assessment and the Wide Range Achievement Test) and sequencing scores (obtained from subtests of the Wechsler Intelligence Scale for Children and the Detroit Tests of Learning Aptitude) of fifty-nine boys (8-13 years of age) who had been placed in junior learning disability classes within the Carleton Public School Board of Ottawa were obtained and subjected to statistical correltion.

The data were analyzed by dividing the independent variables (teacher assessment, WRAT and average reading score) into two extreme groups and carrying out a multi-variate analysis of variance on the four sequencing scores. The following conclusions were reached:

1. Those poor readers who scored lowest on tests of reading ability obtained significantly lower sequencing scores than those poor readers who scored highest on tests of reading ability.

2. Auditory sequencing scores are more closely related to word recognition scores than to teacher assessment or average reading scores.

3. The ability to sequence unrelated digits or words explains more of the variance between relatively low and relatively high reading scores than does the ability to sequence directions or sentences in which experience and interpretation are thought to play a larger part.

4. The fact that auditory sequencing scores are more closely related to the word recognition score, and that digit span explains more of the variance between low and high scores, appears to indicate that: 1) it is the retention of the temporal order of syllables which determines a child's ability or inability to grasp words; and 2) the ability to name digits forward indicates the ability to hear and repeat words, while the ability to repeat digits backward is an indication of the ability to visualize a word in spatial terms long enough to impose auditory symbols and express it verbally. Since the phonetic attack of an unknown word requires the imposition of an auditory sequence onto visual clues, a child who cannot sequence at the most basic level of immediate recall of sounds will be severely hampered in reading skills.

5. Learning disabled children perform less well on measures of pure auditory sequencing of unrelated symbols than when

context clues can be applied.

While the preceding conclusions indicate that the hypothesis has been supported, a more comprehensive study might be conducted to attempt to isolate those things which allow the learning disabled child to perform better on auditory sequencing tasks. If digits backward is truly a task of spatial coordinates, It may prove fruitful to investigate the relationship between the digit span subtest and tests of directionality, laterality and body image in space. The inability to repeat digits backward may co-exist with reversals of letters or inefficient motor skills which require knowledge of directionality, and may prove to be present in many learning disabled children.

To be of any value, the current research must have some valid applications to education; the fact that children in learning disability classes are likely to have deficits in the ability to sequence auditorially should be considered when developing their individual programs. However, this does not mean that these children should be drilled in auditory sequencing skills!

What it does mean is that the teacher must encourage the utilization of other strengths to compensate for this disability. If a child is unable to spell aloud or blend sounds together using only the auditory function, then perhaps he can be encouraged to use visual and motor skills in conjunction with the auditory skills to learn new concepts; if he is confused by the multi-sensory approach, his program might be oriented to capitalize on his visual skills in order to give a success experience rather than continual frustration.

Success experiences in using series of numbers and letters will help an auditorially deficient child learn to utilize those sequencing skills which he does possess. Musical and rythmical presentations of series are much easier to grasp and much more fun than the slow repetition of numbers used in testing. To learn telephone numbers of friends and relatives can be a meaningful experience which enhances the self-concept of a learning disabled child.

The realization that a child with a deficit in auditory sequencing has a great deal of difficulty grasping a series of directions and carrying them out in sequential order is of great importance for the teacher as well as the parent. If he can be given one direction at a time, he can understand what is expected of him in order to gain adult approval. Too often such children are labelled as lazy or disobedient, when the problem is simply one of not grasping the barrage of directions which seem so perfectly clear to the adult.

Children with auditory sequencing difficulties need time to assimilate auditory information and may use stalling techniques in order to give themselves a few more seconds to grasp what was said. With appropriate assistance and consider-ation, all of these children can experience some degree of success in school and at home. The child with an auditory sequencing deficit who is given a limited number of directions and adequate time to respond is able to develop his learning potential with a greater sense of self-accomplishment and worth.

To label a child as a "sequencing problem" accomplishes nothing: to understand his disability is to help him cope with the problem and find other avenues of successful experience.

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The author found that auditory tests were better able to predict low reading ability than were visual tests. She concluded that dyslexia is specifically related to auditory involvement.

APPENDIX 1

Subject	TA	WRAT	Digit S	Words	Sentenc	Directi	Age	IQ	Digits	Digits	Average Readir Score
~~01~~	~~084~~	~~089~~	~~078~~	~~035~~	~~047~~	~~81~~	~~132~~	~~090~~	~~3~~	~~3~~	~~087~~
02	108	099	078	035	048	90	146	094	4	3	104
03	113	129	158	143	144	99	149	096	8	3	121
04	120	115	150	111	084	93	125	114	7	3	118
05	125	116	150	076	063	96	148	105	6	4	121
06	101	097	090	035	036	87	134	104	4	4	099
07	132	137	114	035	078	99	141	104	6	3	135
08	110	121	158	057	045	84	123	079	5	7	121
09	0[illegible]8	091	114	035	156	99	130	105	6	3	090
10	081	081	114	066	111	75	125	115	6	3	081
11	104	105	114	075	036	96	133	120	6	3	105
12	074	075	090	040	078	87	109	101	5	3	075
13	100	097	114	111	096	96	132	126	6	3	094
14	080	096	090	069	078	87	135	104	5	3	088
15	093	101	090	045	072	90	126	082	5	3	097
16	098	104	078	048	039	87	131	093	3	4	101
17	108	109	150	057	057	96	122	115	6	4	109
18	078	074	062	069	063	96	106	097	5	0	076
19	078	080	078	035	035	93	094	089	4	3	079
20	074	078	070	042	036	96	109	095	4	2	076
21	074	071	070	054	075	90	112	090	4	2	073
22	086	089	090	069	057	87	125	114	5	3	088
23	088	104	070	042	035	93	107	101	4	2	096
24	093	090	078	050	045	96	140	092	4	3	092
25	090	090	090	099	081	93	134	107	5	3	090
26	089	090	078	060	057	90	123	093	4	3	090
27	091	116	114	090	072	96	142	095	6	3	104
28	090	102	114	093	126	99	125	109	5	4	096
29	104	105	078	060	072	96	131	111	3	4	105
30	097	105	114	049	054	99	142	093	5	4	101
31	079	085	114	057	060	87	104	092	5	4	082
32	116	110	090	096	060	87	134	096	5	3	113
33	088	089	078	093	0[illegible]1	93	116	091	4	3	089
34	084	089	090	084	078	96	118	111	4	4	087
35	089	096	114	092	081	99	138	095	6	3	093
36	080	081	070	075	075	96	116	095	3	3	081
37	105	105	070	042	078	96	144	080	3	3	105
38	105	111	078	063	057	75	124	101	4	3	108
39	087	091	090	072	060	94	128	113	5	3	089
40	091	096	114	057	045	96	137	086	5	4	094
41	086	089	090	075	054	87	107	106	5	3	088
42	091	101	090	063	039	51	105	090	4	4	096
43	102	101	090	042	084	81	145	092	5	3	102
44	093	109	114	051	072	93	134	081	4	5	101
45	081	079	090	072	069	96	118	092	6	2	080
46	086	110	114	129	053	90	115	087	6	3	098
47	078	080	062	036	039	84	110	064	3	2	079
48	086	089	078	035	045	87	120	093	4	3	088
49	099	101	150	165	120	93	131	089	7	3	100
50	099	099	090	117	078	99	141	090	5	3	099
51	099	127	078	093	069	99	118	077	4	3	113
52	123	144	090	105	126	96	140	118	4	4	134
53	087	101	070	048	048	87	125	093	3	3	094
54	113	137	090	096	054	90	143	085	4	4	125
55	113	115	090	057	051	93	131	100	5	3	114
56	089	092	078	057	081	99	121	107	4	3	091
57	077	097	090	072	074	93	124	111	5	3	087
58	113	109	090	057	078	96	153	085	4	4	111
59	092	093	078	069	045	93	129	051	4	3	093

* All scores (except Digits Forward and Digits Backward) are given in Age Equivalent in months.

Subject - Code number for child
TA - Teacher Assessment of reading ability
WRAT - Wide Range Achievement Score of Reading Recognition
Digit Span - Digit Span Score of the Wechler Intelligence Scale for Children
Words - Attention Span for Unrelated Syllables sub-test of the Detroit Tests of Learning Aptitude
Sentences - Attention Span for Related Syllables of the Detroit Tests of Learning Aptitude
Directions - Oral Commissions of the Detroit Tests of Learning Aptitude
Age - Chronological age in months
IQ - Full Scale Intelligence Quotient Score of the Wechsler Intelligence Scale for Children
Digits Forward - The number of digits correctly repeated in temporal sequence (WISC)
Digits Backward -The number of digits correctly repeated in reverse order (WISC)
Average Reading Score - The Average Score obtained from the Teacher Assessment and the Wide Range Achievement Score

APPENDIX 2

Samples of the Subtests

Test 1: Digits Forward (WISC)

DIGITS FORWARD

Directions Say I am going to say some numbers. Listen carefully, and when I am through say them right after me.

The digits should be given at the rate of one per second. All Subjects should be started with the 3 digit Series.

If the Subject repeats Trial I of a Series correctly, it is scored plus and the next higher Series is given. If the Subject fails on Trial I he is given Trial II of the same Series.

Discontinue Failure on both Trials of a given Series.

Scoring Score is the *highest* number of digits repeated without error on either Trial. Thus if the highest number of digits correctly repeated by a Subject is five digits forward, his score is 5. Maximum score 9 points.

Digits Forward

Series	Trial I	Trial II
(3)	3-8-6	6-1-2
(4)	3-4-1-7	6-1-5-8
(5)	8-1-2-3-9	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

Test 2: Digits Backward (WISC)

DIGITS BACKWARD

Directions Say *Now I am going to say 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?* Pause for Subject to respond.

If he responds correctly, say *That's right*, and proceed with the test, beginning with Trial I of the 3-digit Series.

But, if he fails the example, give him the right answer and try another example, saying *Remember, you are to say them backwards; 5-6-3.* If he succeeds this time, proceed with the test using Trial I of the 3-digit Series. However, if he fails this second example, proceed with the test, but begin with Trial I of the 2-digit Series.

Some Subjects who pass the unrecorded examples may fail *both* Trials of the 3-digit Series; in this case give the Trials of the 2-digit Series and then stop. Give the second Trial of a Series only if the first Trial is failed.

Discontinue Failure on both Trials of a given Series.

Scoring Score is the highest number of digits repeated backwards without error. Maximum score: 8 points.

Total Score for Digit Span Test Sum of scores on *Digits Forward* and *Digits Backward*.

Maximum score: 17 points.

Digits Backward

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

Test 3: Words (Detroit Tests of Learning Aptitude)

Test 6, Auditory Attention Span for Unrelated Words

See: Page 5 of Pupil's Record Booklet

Material:—Two sets of unrelated, one-syllable words—set "a" and set "b"—given on page 5 of Pupil's Record Booklet. Each set contains seven groups of words, the groups increasing in number of words from two to eight.

Procedure:—Say, "I am 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 'c o . . . ice.'" After pupil responds, proceed with the next series.

Say the words in each group at the rate of one word per second. After each set allow time for pupil to repeat the words. Do not allow pupil to start until all the words of a group have been given by the examiner.

Record the response by placing a number above each word indicating *the order* in which he repeats them;

1 2 3
e.g., man—horse—song.

Continue in this manner through the entire group of words.

6. Auditory Attention Span for Unrelated Words

(See pages 33 34 of Handbook)

Score: Simple .

Weighted -

2 a cat ice

2 b dog ship

3 a man horse song

3 b pen [illegible] cow

4 a cart bird desk road

4 b chair hen book vest

5 a head milk dress oats night

5 b pipe west fence coat mule

6 a fish clock heart sun box frog

6 b stone blot freeze door cut white

7 a skirt plant friends east tub barn hair

7 b mud vase north ten rain cross shoe

8 a ear boat key pig south knob ink rope

8 b flour skate fan spend lamp wool axe toad

APPENDIX 2

Test 4: Sentences (Detroit Tests of Learning Aptitude)

Test [illegible], Auditory Attention Span for Related Syllables

See: Page 9 of Pupil's Record Booklet

Material:—A series of 43 sentences, ranging from five words of six syllables to twenty-two words with twenty-seven syllables, given on page 9 of Pupil's Record Booklet.

Procedure:—Say, "I am going to say something to you. When I get all through, you say just what I said."

Say each sentence slowly and distinctly. Do not repeat it. After each sentence, allow time for the pupil to repeat it. (See general suggestions for Test No. 2, page 31.) Start with sentences where success is obvious, continue until there are three sentence failures in succession.

Record responses on the Pupil's Record Booklet by crossing out any words omitted and by inserting any additional words or syllables.

Scoring:—A sentence is failed when there are three or more errors. There are three kinds of errors:

(a) a word omitted; (b) a word added; (c) an unsuitable word substituted. In determining failure, the errors may all occur in a, or b, or c, or in any combinations of a, b, and c.

Scoring: *Three points* for each sentence with *no* errors. (Credit three points for each sentence before the place where the testing began.)

Two points for each sentence with *one* error of any type.

One point for each sentence with *two* errors of any type or combination of types.

No credit for each sentence with *three or more* errors of any type or combination of types.

Maximum Score: 129 points.

APPENDIX 2

13 Auditory Attention Span for Related Syllables

(See page 69 of Handbook)

Score. . . ..

My doll has pretty hair. 2. We will go for a walk. 3. My dog chases the white cat.

4. Our new car has four red wheels. 5. Henry likes to read his new book.

6. Bring the broom and sweep the front room. 7. The bell on the engine rings loudly.

8. On Sundays all of us go to church. 9. In summer we go North where it is cool.

10. Green leaves come on the trees in early spring 11. The airplane makes a loud noise when it flies fast.

12. We saw a little fire on the way to school. 13. The sun shone brightly today and it hurt my eyes.

14. The men painted our new house white with dark green blinds.

15. They gave me some pretty shoes for my birthday last month.

16. The art teacher comes to our own school three days a week.

17. Ten persons went to a party where there was lots to eat.

18. Three boys spent a happy day last week on a fishing trip.

19. On Tuesday for lunch we had some fresh bread which our mother baked.

20. Father must buy some new license plates for his car once each year.

21. When the train passes the whistle blows for us to keep off the track.

22. In the summer time the nights are very short and the days are long.

We had a party for Jean last Monday with cake and ice cream to eat.

At night we go to bed and mother reads to us from our story books.

25. Each year when the big circus comes to town father takes the whole family.

26. Many boys and girls go to the movies on nights at the end of each week.

27. My sister Mary has a pretty new doll which shuts its eyes and goes to sleep.

28. The man who lives next door is a good neighbor and invites us for many rides.

29. Last winter we made a big round snow man and put a little black hat on his head.

30. In my uncle's home there was a soft red carpet on the floor of the living room.

31. The day of the football game the weather was clear but chilly and the wind blew briskly.

32. Because there were few vacant lots the police roped off our street so that we might be safe.

33. On the Fourth of July my father puts on his army suit and joins his friends on parade.

34. In fair weather and at high tide ships from many nations set sail for their own distant ports.

35. The baseball team from our high school played fifteen games; they lost six but they ended in second place.

36. Last night there was a large banquet at the hotel where many people dined and had a pleasant time.

37. Our reading books at school have many fine stories which are short but very full of life and action.

38. In the north country the days are very short in winter and the sun hangs low in the southern sky.

China closets filled with all kinds of dainty dishes and cut glass lined the large walls of the dining room.

On cold, clear nights hundreds of thousands of twinkling stars shine brightly from their cradles far up in the sky.

In the heart of the Congo there are many kinds of beasts which are a mighty terror to the black natives.

42. Down near the bank of the river is an estate from which sound the shouts of happy children hour after hour.

43. Each four years voting takes place which results in many men being placed in office for terms of two years or more.

Test 5: Directions (Detroit Tests of Learning Aptitude)

Test 5, Oral Commissions

See: Page 5 of Pupil's Record Booklet

Material:—A series of commissions, the units increasing in number from one to four given on page 5 of Pupil's Record Booklet. Common objects in the room; a book, pencil, penny, and piece of paper.

Procedure: - Say, "I am going to tell you some things to do. You listen and do just what I tell you to do *after I get all through.* Listen."

Give the commissions slowly allowing from ten to fifteen seconds for the pupil to do what is requested of him in the test.

Avoid any suggestion such as nodding toward or gazing at the object after directions are completed.

Give the entire series.

Scoring:– Give one point for each commission correctly executed if done in correct order with respect to the others of the same group.

In a group of three commissions if one only is correct, give one point credit. If two are correct in a set of three in correct order such as first and second, or second and third, or first and third, give two points. If three are in the order of second, third and first, give a credit of two points, not allowing credit for the first point which is out of correct order.

Maximum score 20 points

7. Oral Commissions

Score... ... .

(See pages 34-35 of Handbook)

1 a Show me the window.

b Stand up straight.

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

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

3 a 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

4 a 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.

APPENDIX 2

Test 6: Word Recognition (Wide Range Achievement Test)

Reading—Level I

The reading subtest consists of the following parts

At the pre reading level

1. Naming 2 letters in previously written or printed name
2. Identifying 10 letters by form
3. Naming 13 letters of the alphabet

At the reading level.

1. Pronouncing 75 words

In children of 8 years and older, the reading subtest may be begun with the word pronunciation part. Two copies of the test blank are used, one for S to read from, and one (with personal data filled in) for E to record on.

Directions: Point to the first word and say: **Look at each word carefully and say it aloud. Begin here (point) and read the words across the page so I can hear you. When you finish the first line, go on to the next line and then the next.** In the case of young children and retarded adults, each word may have to be pointed to with a pencil while S attempts to read.

Time Limits: 10 seconds per word

The reading part should be administered with as few interruptions as possible. Any clearcut response should be accepted and scored as either right or wrong. The first time an error is made, S is asked to say the word again. His response is scored right if he corrects himself on the second trial. From then on, the first response is scored as either right or wrong, unless S spontaneously corrects the error he has made. If the response is not clear or is unscorable, E may ask S to repeat the word. E should not intimate, by either motion, word, or emotion, that he is dissatisfied with the answer. Teaching, coaching, or questioning should be strictly avoided. The reading rate may be controlled by E. Saying "next" at the end of the time limit of 10 seconds is a convenient way of controlling the performance. Refusals to read within time limits should not always be accepted as evidence of failure. If S hesitates or says "I don't know that", E should encourage S to **"try the word anyway or take a guess at it".**

Testing Limits: 12 consecutive failures

Percentiles and Standard Scores corresponding to grade rating and age may be found in the Manual

Level I—Reading—Grade Norms.

Score	Grade	Score	Grade	Score	Grade	Score	Grade	Score	Grade	Score	Grade	Score	Grade
5		16-17	Kg 6	36 37	1.9	51	4.4	66	[illegible]	79	8.1	92	12.9
4		18	Kg 7	38	2.0	54	4.5	67	5.5	80	8.4	94	13.3
[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	13.7
2		21	Kg 9	41	2.2	56	4.8	69	5.9	82	9.0	95	14.1
4		22	Gr 1.0	42-43	2.4	57	4.9	70	6.1	84	[illegible]	96	14.5
6	Pk 5	24	1.1	44	2.4	58	4.1	71	6.3	84	9.7	97	14.9
7	Pk 7	24 25	1.2	45 46	2.5	59	4.2	72	6.5	[illegible]	10.1	98	15.4
8	Pk 9	26 27	1.3	47	2.6	60	4.4	73	6.7	86	10.5	99	15.8
9	Kg 1	28-29	1.4	48	2.7	61	4.5	74	6.8	87	10.9	100	16.2
10 11	Kg 2	30 31	1.5	49	2.8	62	4.7	75	7.0	88	11.3		
12	Kg 3	32 33	1.6	50	2.9	63	4.8	76	7.2	89	11.7		
13 14	Kg 4	34	1.7	51	3.0	64	5.0	77	7.3	90	12.1		
15	Kg 5	35	1.8	52	3.1	65	5.1	78	7.8	91	12.5		

Level II—Reading—Grade Norms

Score	Grade	Score	Grade	Score	Grade	Score	Grade	Score	Grade	Score	Grade	Score	Grade
0	Pk [illegible]	16	1.4	29	4.4	42	6.8	55	9.3	69	13.0	81	16.9
1	Pk 8	17	1.5	30	4.6	43	6.9	56	9.6	60	13.2	82	17.1
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	70	13.5	83	17.4
3 4	Kg 2	19	1.8	32	5.0	45	7.3	58	10.2	71	13.8	84	17.7
5 6	Kg 4	20	2.0	33	5.2	46	7.5	59	10.5	72	14.1	85	18.0
7	Kg 4	21	2.2	34	5.4	47	7.7	60	10.8	73	14.4	86	18.3
8	Kg 5	22	2.4	35	5.6	48	7.9	61	11.1	74	14.7	87	18.6
9	Kg 6	23	2.6	36	5.8	49	8.1	62	11.6	75	15.0	89	19.0
10 11	Kg 7	24	2.8	37	6.0	50	8.3	63	11.9	76	15.3	89	19.5
12	Kg 8	25	3.2	38	6.2	51	8.5	64	12.2	77	15.6		
13	Kg 9	26	3.5	39	6.3	52	8.7	65	12.4	78	15.9		
14	Gr 1.0	27	3.7	40	6.5	53	8.9	66	12.6	79	16.2		
15	1.1	28	4.2	41	6.6	54	9.1	67	12.8	80	16.5		

LEVEL 2

Two letters in name (2) A B O S E R T H P I U Z Q (13) 15

milk city in tree animal himself between chin split form 25

grunt stretch theory contagious grieve toughen aboard triumph 33

contemporary escape eliminate tranquillity conspiracy image ethics 40

deny rancid humiliate bibliography unanimous predatory alcove 47

scald mosaic municipal decisive contemptuous deteriorate stratagem 54

b-nign desolate protuberance prevalence regime irascible peculiarity 61

dist enigmatic predilection covetousness soliloquize longevity abysmal 68

atiating oligarchy coercion vehemence sepulcher emaciated evanescence 75

centrifugal subtlety beatify succinct regicidal schism ebullience 82

misogyny beneficent desuetude egregious heinous internecine synecdoche 89

LEVEL 1

cat see red to big work book eat was him how 16

then open letter jar deep even spell awake block size 46

weather should lip finger tray felt stalk cliff lame struck 56

approve plot huge quality sour imply humidity urge 64

bulk exhaust abuse collapse glutton clarify 70

recession threshold horizon residence participate quarantine 76

luxurious rescinded emphasis aeronautic intrigue repugnant 82

putative endeavor heresy discretionary persevere anomaly 88

mentary miscreant usurp novice audacious mitosis 94

ograph spurious idiosyncrasy itinerary pseudonym aborigines 100

A R Z H I Q S E B O 10

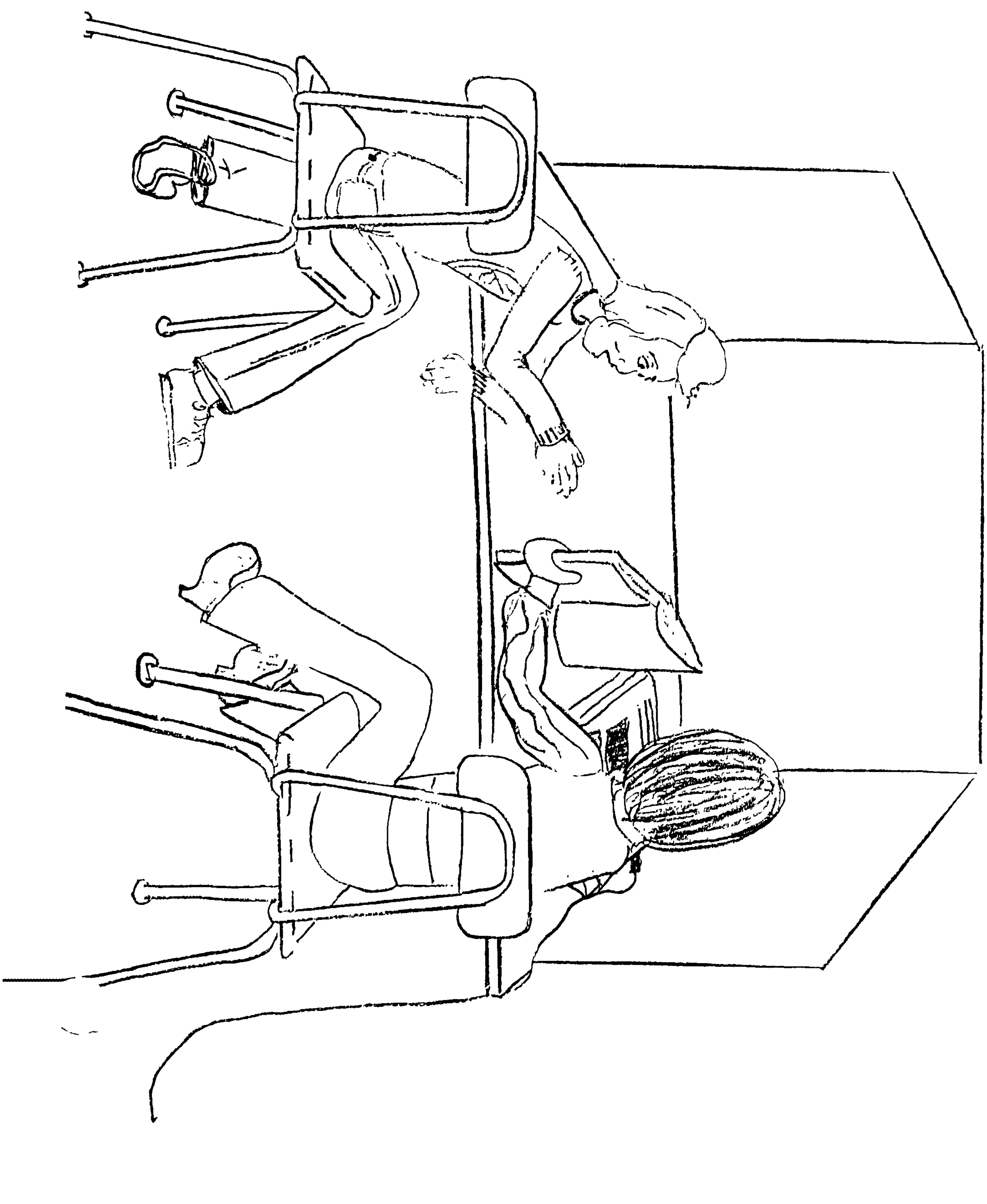
Two letters in name (2) A B O S E R T H P I U Z Q 25

APPENDIX 2

Test 7: Teacher Assessment of Reading Ability

The teacher is asked to assess the child's level of functioning in reading.

"At what level is the child able to read when he is reading with you on an individual basis?"



APPENDIX 4

HOW TESTS WERE GIVEN AND PERFORMED

Test 1: Digits Forward of the WISC was performed exactly as written in the 1949 manual. Digits were presented at the rate of one per second with all subjects commencing with the three-digit series. If the subject responded correctly, the test was scored plus and the next higher series was given. If he failed trial 1, he was given trial 2 of the same series. If he failed both series, the test was discontinued and he received the score for the highest number of digits repeated without error.

Test 2: Digits Backward of the WISC was given as directed in the 1949 manual. If a child responded correctly to the three-digit example, testing commenced with three digits backward. If he failed two sequences of three digits backward, the test commenced with two digits backward. The test discontinued with failures on both trials of a given series, and the subject received a score for the highest number of digits repeated backwards without error.

Test 3: The Auditory Attention Span for Unrelated Words was presented at the rate of one word per second. A child was asked to repeat unrelated one syllable words commencing with two in a row. He was not allowed to start until all the words of a group had been given. The response was recorded by placing a number above each word indicating the order in which they were repeated. The child was required to attempt the entire group of words, up to and including a series of eight words in a row.

Test 4: The Auditory Attention Span for Related Syllables is a series of forty-three sentences beginning with five words of 6 syllables. Each sentence was read slowly and distinctly only once. A child was given time to repeat each sentence. The test was continued until there were three failures in succession, a failure being defined as three or more errors. These errors could be:

1) words omitted; 2) an unsuitable word substituted; or 3) a word added. A child received three points for each sentence with no errors, two points for each sentence with 1 error of any type, one point for each sentence with 2 errors of any type or combination of types, and no credit for a sentence with 3 or more errors of any type or combination of types.

Test 5: The Oral Commissions test requires the subject to follow a series of directions beginning with one at a time. The directions are given slowly and distinctly allowing the subject ten to fifteen seconds to do as requested. The complete series is given up to and including four directions. One point is given for each action carried out in correct order.

Test 6: The Word Recognition subtest of the WRAT requires a child to look at each word carefully and say it aloud. The first time an error is made, the child is asked to try again and if he corrects it, he is credited with a correct response. From then on, the first reponse is scored as correct or incorrect. The child is given ten seconds for response before the examiner goes on to the next word. The child begins reading the first line of the words and continues until he makes twelve consecutive errors. If a mistake is made on the first line, the child is given the pre-reading section of the test which involves the recognition of letters.

APPENDIX 5

ABSTRACT OF

Auditory Sequencing as it Pertains to the Learning Disabled Child

A review of the literature indicated that a deficit in the ability to hold in mind the structure of an auditory stimuli long enough to repeat it in temporal order, or in reverse order, was an important factor in causing reading problems.

The purpose of the current research was to determine whether the inability to sequence at the most basic level (auditory sequencing) was common to all children who had been placed in junior classes for children with learning disabilities.

Measures used in the current study of fifty-nine boys (8-13 years of age) who had been placed in junior learning disability classes were reading scores (Wide Range Achievement Test of Reading Recognition and teacher assessment of reading ability) and sequencing scores (obtained from subtests of the Wechsler Intelligence Scale for Children and the Detroit Tests of Learning Aptitude).

The data were analyzed by dividing the independent variables (teacher assessment, WRAT and average reading score) into two extreme groups and carrying out a multi-variate analysis of variance on the four sequencing scores. Based on the results the hypothesis that learning disabled children with low reading

ability would also have low auditory sequencing skills was accepted.

The fact that auditory sequencing scores were more closely related to the word recognition score, and that digit span explains more of the variance between low and high scores appears to indicate that: 1. it is the retention of the temporal order of syllables which determines a child's ability or inability to grasp a word, as word recognition appears to be a task of imposing an auditory sequence onto a visual clue and retaining that sequence to grasp the total word; and 2. the ability to name three digits forward indicates an ability to hear and repeat words, while the ability to name digits backward indicates an ability to visualize a word in spatial terms long enough to impose auditory symbols and express it verbally.

A child who cannot sequence at the most basic level of immediate recall of digits also has low scores on tasks which require more advance skills such as reading. It is the contention of the current research that it is the ability or inability to reproduce the necessary sequence of sounds which determines in large part a child's ability to read.

To conclude the study, the findings were interpreted to frame recommendations to help children with problems in auditory sequencing in the classroom and in the home.