AN EXAMINATION OF THE IMPORTANCE OF AUDITORY-VISUAL INTEGRATION, VISUAL-AUDITORY INTEGRATION, AUDITORY MEMORY, AND VISUAL MEMORY TO ORAL READING

By

LEO VINCENT RODENBORN, JR.

Bachelor of Arts
University of Northern Iowa
Cedar Falls, Iowa
1959

Master of Science
Oklahoma State University
Stillwater, Oklahoma
1966

Submitted to the Faculty of the Graduate College
of the Oklahoma State University
in partial fulfillment of the requirements
for the Degree of
DOCTOR OF EDUCATION
August, 1969

AN EXAMINATION OF THE IMPORTANCE OF AUDITORY-
VISUAL INTEGRATION, VISUAL-AUDITORY
INTEGRATION, AUDITORY MEMORY, AND
VISUAL MEMORY TO ORAL READING

Thesis Approved:

Darrel D. Ray
Thesis Adviser

Bernard A. Belden

Robert S. Brown

Sue Hawkins

B. Curtis Hamm

D. D. Durham
Dean of the Graduate College

ACKNOWLEDGMENTS

The writer wishes to express his sincere appreciation to the many people who have contributed, directly and indirectly, to this dissertation. Special appreciation is extended to Dr. Bernard R. Belden for his encouragement and aid through four years of graduate study. Without his guidance and assistance this dissertation would never have been undertaken.

Dr. Darrel D. Ray, Chairman of the writer's Advisory Committee, has continually striven to draw forth the best effort from his students, and a special appreciation is extended to him for his many thoughtful critiques throughout this study.

Dr. Robert S. Brown has been especially kind in aiding the writer to design the study and prepare this paper. To him and the other members of the advisory committee, Dr. Sue Hawkins, Dr. Bernard R. Belden, and Dr. B. Curtis Hamm, appreciation is expressed for their thoughtful assistance.

The efforts of Mr. David K. Williams of the Oklahoma State University Speech and Hearing Clinic are greatly appreciated. His help in the preparation of the tape recorded auditory stimuli used in this study was most kind.

Special thanks is given to Mr. Jack A. Davis, Superintendent of Schools, Mr. Coyle F. Smith, Elementary Principal, Mr. Ival L.

Stafford, Counselor, and the elementary teachers and students of the Pawnee Independent Schools in Oklahoma for their kind cooperation.

This study is dedicated to the writer's patient wife, Sonni, and to his children Brian, Delores, Barton, Brent, Bradley, Bruce, Blair, and Deon in tbe hope that they will some day write an acknowledgment for a dissertation.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

CHAPTER I

PRESENTATION OF THE PROBLEM

Introduction

Over the years there has been a great deal of research into the etiological factors in reading disability. This research has attempted to uncover the cause or causes of such disabilities with the dual purposes of remediating present cases of reading disability and predicting potential cases of reading failure in order to prevent their occurrence.

Various theories have been advanced, from time to time, to explain why some children experience great difficulty in learning to read. These theories seem to cluster into four discrete categories:

1. correctable physical deficiencies ranging from obvious defects of vision or hearing to more subtle theories of glandular misfunctioning;

2. environmental inadequacies leading to emotional disorders, to cultural deprivation with language deficiencies, or to failure in the teaching-learning situation caused by an inappropriate matching of the student to materials and methods;

3. a suspected neurological malfunctioning caused by either minimal brain damage or improper neurological development; and

4. perceptual weaknesses (without necessarily a concern for causation) which could be defined as deficiencies in the component abilities required to translate printed symbols into meaningful understanding within the individual, as measured by overt responses made by the individual.

This fourth category, perceptual weaknesses, has been extensively researched over the years. Most researchers have found these factors to be significantly related to success or failure in reading, and some investigators have included perceptual deficiencies as symptoms of reading disability. This investigation explores several percpetual factors to extend the research in this area.

Background of the Study

Sievers (1955) developed a Differential Language Facilities Test based on a psychological theory of language acquisition and use as formulated by Osgood (1957). Kirk and McCarthy (1961, 1968) have developed the Illinois Test of Psycholinguistic Abilities (I.T.P.A.) as an extension of the Sievers' test. Based on a slight modification of Osgood's theory, the I.T.P.A. was designed to provide an instrument for differential diagnosis of impairments in the communicative processes. The intent of the creators of this type of test is to enable clinicians to diagnose specific weaknesses in component abilities in order that proper remedial therapy may be applied.

While the I.T.P.A. was intended to be an instrument to assess language abilities, Kass (1966) attempted to extend its use to disabled readers by adding several sub-tests to the experimental test battery.

The 1968 revision of the I.T.P.A. added three sub-tests in an apparent effort to make the test more useful in diagnosing reading disability cases. Kirk, McCarthy, and Kirk (1968, page 5), however, feel that their test should be considered a diagnostic instrument for assessing difficulties in the processes of communication and should not be regarded as a test for diagnosing reading disabilities.

The development of the I.T.P.A. points out the need for a similar type of test for differential diagnosis of reading problems. Such a test should be based on a suitable model of psycholinguistic abilities and processes that are involved in reading. While there is at present no generally accepted model of these reading processes and abilities, a wealth of research has tentatively identified some of the abilities likely to be involved in the reading act.

Auditory memory span and visual memory are two of the abilities which have been considerably studied and consistently reported to be highly correlated with reading ability. This paper presents an exploration of these two abilities as well as two newer constructs: auditory-visual and visual-auditory integration.

Auditory-visual integration is a recently posited construct of reading proposed by Birch and Belmont (1965, pages 290-297), who define it as, "....the ability to equate a temporally structured set of auditory stimuli with a spatially distributed set of visual ones." In this test of AVI, patterns of pencil taps were sounded out with either a short or long pause between the taps. The subjects listened to this auditory standard of taps, then looked at three different patterns of dots printed on cards, and chose the visual pattern of dots that was equivalent to the auditory standard.

Visual-auditory integration requires the ability to match a visual standard of dots with an auditory pattern of sounds. In this type of test, the child looks at a visual standard which is presented and then removed, listens to a sound pattern of dots, and decides whether the two patterns were the same or were different.

Since auditory-visual integration is only a recently explored ability and visual-auditory integration has received only limited attention in research, both of these constructs warrant further investigation to determine their importance for inclusion in a suitable model of reading processes.

Statement of the Problem

In a standardization study of a test of auditory-visual integration, Birch and Belmont (1965) reported that this ability had its most rapid growth between the ages of five and seven. Growth then continued more slowly and indicated small increments in ability from ages seven to eleven, with no further increase in ability noted after this age. In a previous study (Birch and Belmont, 1964), these investigators concluded that auditory-visual integration was an important sub-ability in reading and that disabled readers were deficient in this ability when compared to normal readers.

Other investigators have concluded that auditory memory, visual memory, and visual-auditory integration, are all highly important to reading growth; and deficiencies in these abilities are often thought to be causative factors in reading disability, or to be indicative of children who have special handicaps in learning to read.

The purpose of the present investigation was to examine auditory-visual integration in conjunction with the three constructs of reading ability mentioned above to determine: (1) the nature and developmental growth of these constructs; (2) the existing interrelationships among these abilities; (3) the factorial composition of these abilities; and (4) the effectiveness of using these constructs to estimate oral reading performance.

Hypotheses

In order to fully examine the four constructs of sub-abilities in reading, the following hypotheses were stated:

1. There are no significant differences among the mean IQ scores of the grade levels in this study.

2. There are no significant differences between the mean IQ or oral accuracy scores of the boys and girls at each grade level in this study.

3. There are no plateaus indicating a cessation of further growth in the developmental curves for the four constructed tests.

4. There are no indications from the developmental curves for the four constructed tests that growth in these abilities is most rapid in the initial segment of these curves.

5. There are no significant differences between the mean scores on the four constructed tests of the boys and girls at each grade level in this study.

6. There is no significant correlation between the tests of AVI and VAI; and there are no significant correlations between either of

these tests and auditory memory, visual memory, age grade, or mental grade.

7. There is no factor which accounts for most of the variance in the factor analysis of results from the four constructed tests, oral accuracy, and oral comprehension.

8. There are no significant contributions in estimating the reading scores made by adding any of the four constructed tests to mental grade in multiple regression equations.

9. There are no significant contributions in estimating the reading scores made by any of the four constructed tests when all four are added to mental grade in multiple regression equations.

Definition of Terms

The following are definitions of terms as they are used throughout this report:

Auditory-visual integration, or AVI, is the ability to listen to an auditory standard, composed of pre-recorded sounds of short or long duration with short or long spaces between the sounds, and then choose from among three visual patterns of dots and dashes the equivalent pattern.

Visual-auditory integration, or VAI, is the ability to decide whether a visual standard of dots and dashes, which has been presented first, has been matched by an auditory pattern of short and long sounds and spaces.

Auditory-memory in this report refers to the ability to repeat exactly sequences of digits presented auditorily at a rate of two per second. This construct of mental ability is often referred to as short-term memory or the memory span.

Visual-memory in this report refers to the ability to identify exact sequences of visually presented letters in nonsense-type words which contain no vowel letters. The child looks at a visual standard and chooses from among a group of five distractors the exact match of the standard.

Age grade refers to the expected grade placement for a child based on his chronological age and is computed by subtracting five years from the child's attained age. This corrected grade score removes problems caused by children who had been repeaters in a grade, double promoted, too young for their actual grade placement, or too old for their grade placement.

Mental grade refers to the mental age of the child, based on the California Test of Mental Maturity, minus five years. This correction factor produces grade level scores that are equivalent to the expected grade level for the child based on his mental age.

IQ refers to the intelligence quotient from the California Test of Mental Maturity (California Test Bureau, 1963) for total score. This total score includes a weighting of both verbal and nonverbal intelligence scores.

Oral accuracy refers to the raw score for oral accuracy from the Gilmore Oral Reading Test (Harcourt, Brace and World, Inc., 1951). In this test the child reads successively more difficult passages until a ceiling level is reached when more than ten errors in accuracy have been made. The score is computed by subtracting the number of errors made on a passage from ten and adding the remaining points for each passage.

Oral comprehension refers to the raw score for comprehension from the Gilmore Oral Reading Test (Harcourt, Brace and World, Inc., 1951), with raw score modifications.[1] On this test the child was asked five comprehension questions on each passage read. The oral comprehension score was the total number of questions answered correctly, plus credit for those passages which were not read by the child.

Delimitations

Scope of the Study

This study is an analysis of the performance of elementary school children on various tests designed to tap specific variables which may be essential abilities in reading. The children's performances on tests of auditory-visual integration, visual-auditory integration, auditory memory, and visual memory were examined to answer the questions raised in the Statement of the Problem and to test the hypotheses of the study.

The children in this study were randomly selected from the elementary school children in a small town in north central Oklahoma, who had scored within the first standard deviation (IQ scores for total between 85 and 115) on the California Test of Mental Maturity. The sample was stratified to include fifteen boys and fifteen girls at each of the six elementary grade levels.

---

[1]These raw score modifications are explained completely in Chapter III under Standardized Test Instruments. The scoring procedure was to give credit for comprehension on only those passages that were actually read by the child or were below his basal level. This procedure is different from the manual directions with this test.

Limitations of the Study

Since the sample size of thirty children at each grade level is small, and since the population of children from which the sample was selected was limited to a small town in Oklahoma, generalizing from this study to other populations will be exceedingly tenuous.

There are other ways to test the abilities measured in this study. Consequently, the obtained results apply only to those exact measures that are the basis of this investigation.

Other reading measures, such as silent reading tests, are often used in studies concerned with reading sub-abilities. Only the reading performance as indicated was measured in this study; and other types of reading tests might yield different results from those obtained in this study.

The type of reading instruction that children receive in their schools may to an extent be reflected in the development of various abilities in reading. Bond (1935) found that the methodology used in schools accounted for differences in auditory abilities of children who were reading failures in different schools. The children in this sample have basically received reading instruction in a phonics-first type of program. The Phonetic Keys to Reading (The Economy Company, 1964), which teaches isolated letter sounds initially and gradually develops decoding skills through the synthesizing of these sound elements, was the instructional approach used by all teachers in this school. Thus, the results of this study may be better indicators of performance abilities for children who have received comparable reading instruction.

Removing children from their regular classroom for testing creates an unnatural situation and may result in biased test scores. While this is the typical procedure for such testing, this possible source of errors should not be overlooked.

The use of tape-recorded auditory stimuli provided a constancy of test procedure, but again an unnatural situation for the child results. The use of recorded directions and sample items may have removed part of the effects of an unusual situation for the child, but errors in measurement may well have been introduced in this study.

Assumptions of the Study

It is assumed that the four constructed tests in this study had content validity and were measuring constructs of reading ability.

It is assumed that the raw score modifications explained in the Definition of Terms provided valid measurement of the oral comprehension score.

It is assumed that any chance factors which occurred during the testing situations were no greater than those encountered in any testing situation.

Significance of the Study

This study reports an investigation to determine the importance of four constructs of reading abilities to oral reading performance, a criterion often considered by teachers and clinicians to be a valid standard for judging the competency of children in reading. Thus, the findings of this study will have special relevance for both those who teach reading initially and those who work with children with reading problems.

This investigation provides a study of the characteristics of tests of integration abilities and the growth pattern of these abilities in a sample of children with normal ability. An important addition to studies of integration abilities, which is included in this study, is providing a measure of both auditory and visual short-term memory. These measures allow a greater in-depth exploration of the integration abilities to assess their importance to reading.

The use of both age grade and mental grade in the construction of growth curves for the tests of those sub-abilities removes some possible sources of errors contained in other studies. The addition of growth curves for these abilities as examined by both oral accuracy and oral comprehension performance provides another view of these component abilities and how these abilities may be related to reading growth.

Since any model of reading abilities and processes needs to include all important sub-abilities of reading growth, this study should help answer questions concerning the importance of integration abilities, as they are currently being tested, to reading development.

Organization of the Study

Chapter I has presented the background of this study, a statement of the problem to be explored and the hypotheses to be tested, the delimitations of the study, and the significance of this study to teachers, clinicians, and researchers.

A review of the literature of studies that pertain to integration abilities, the measurement of memory span, auditory memory span, and visual memory is contained in Chapter II, as well as a summary of this literature with the implications for other research.

Chapter III discusses the sample selected, the test instruments employed and the testing procedures, and the statistical techniques used to test the hypotheses.

Chapter IV analyzes and illustrates the test data and statistical treatment of it as necessary to the testing of the hypotheses.

Chapter V includes a summary of the study, the conclusions drawn from this research by the testing of the hypotheses, a discussion of these conclusions, and some recommendations for future research in this area.

Summary

This chapter has presented the background for this study, which included a statement of the need for further research into the component abilities of reading.

The stated problem to be investigated in this study was an exploration of four constructs of reading ability: auditory-visual integration, visual-auditory integration, auditory memory, and visual memory. To be determined were the nature and developmental growth of these abilities, the existing interrelationships among these abilities and their factorial composition, and the effectiveness of these constructs in estimating oral reading performance.

Eight hypotheses were stated for ease in answering the questions raised in the statement of the problem; the terms used in the study were defined; the delimitations of the investigation were enumerated; and the significance of the study was explained.

Chapter II will now give the review of literature made for this study, and how this review shaped the rest of the study.

CHAPTER II

REVIEW OF THE LITERATURE

The literature reviewed in this chapter will be organized into five sections for convenience in presentation: (1) literature dealing with the integration abilities; (2) literature on the measurement of memory span; (3) literature concerned with auditory memory; (4) literature dealing with visual memory; and (5) a general summary of this literature with the implications for this study. A short summary will also follow each of the first four sections.

Integration Abilities

Within the last few years, researchers have begun to investigate the possibility that reading disability may be related to a difficulty in making transfers between the visual and auditory senses. The inability to equate what is seen with what is heard is thought to be either contributory to reading disability or indicative of children with such learning problems. Since the normal procedures for teaching reading require children to tie sounds or spoken words with visual symbols, this theory is currently receiving a great deal of attention in the journals.

Birch and Belmont (1964) reported on a test of auditory-visual integration which required subjects to equate sound patterns of pencil taps with visual patterns of dots. In 200 Scottish children, of whom

150 were retarded and 50 were normal readers, Birch and Belmont found that the retarded readers were less able to perform on the test of integration than were the normal readers.

These authors also reported that the integration ability measured seemed to be a process closely related to intelligence, but, even when the effects of IQ were eliminated by considering only those children who had IQ scores of over 100, poor readers were significantly less able to do the integration tasks than were normal readers.

While this integration ability could distinguish between normal and retarded readers, Birch and Belmont concluded that this was not the only important factor in reading disability. Some normal readers were poor at making these equivalency judgments and some poor readers were able to perform quite well on this task.

In a further study of their AVI test, Birch and Belmont (1965) reported on the development of this integration ability in 220 elementary school children from kindergarten to sixth grade. These investigators found that improvement in this ability was most rapid in the first few school years, and then growth in integration ability seemed to suggest small increments until a plateau level occurred sometime after fifth grade. However, the authors realized that this plateau might very well be caused by the nature of the test, since it contained only ten items and might not have allowed for continued age-specific growth.

Birch and Belmont also suggested that the functions between AVI and reading and IQ and reading were quite different. Correlations between IQ and reading were quite different. Correlations between IQ and reading ability increased with age in their study, but correlations between

AVI and reading decreased with age. However, these results may have been caused by the nature of the test used, as mentioned above.

Muehl and Kremenak (1966) reported on the results of the second author's doctoral study which investigated prereaders' integration abilities and later reading success. Four tests were used in this study: V-V and A-A were integration tasks within a modality, and V-A and A-V were integration tasks between modalities.

In this study, 119 first grade children were tested on the four integration tests and a readiness test in the fall and on an IQ test and an achievement test in the spring. Results of the study indicated that the A-A test was most difficult, the V-A and A-V were next in difficulty, and the V-V was the easiest test presenting little difficulty for any subject. Both the V-A and A-V integration tasks contributed significantly to predicting reading success, and the ability to integrate auditory with visual stimuli was significantly related to later reading success with the IQ held constant.

In an unpublished doctoral study at Columbia University, Kahn (1965) studied auditory-visual integration in 350 boys with 70 at each grade level from 2 to 6. The test used was an extension of the one devised by Birch and Belmont (1964, 1965) and contained 20 test items. Scores on this test were studied in relation to the Digit Span from the <u>WISC</u> and a silent reading test.

Kahn found that AVI correlated with chronological age at .51 and with reading at .37 to .57 at different grade levels, and with IQ held constant, AVI was a significant predictor of word knowledge but not of reading comprehension. His conclusion was that the test of AVI was measuring an important correlate of reading achievement.

Sterritt and Rudnick (1966) raised questions about the methodology employed by Birch and Belmont in their studies. Because the auditory patterns used by Birch and Belmont were created by tapping out patterns in view of the subjects, Sterritt and Rudnick felt that this type of test might be measuring a visual to visual integration. These investigators also questioned Birch and Belmont's failure to use more powerful statistical techniques in controlling for intelligence.

In the Sterritt and Rudnick study, 36 fourth grade boys were tested on three integration tests. One of these was a replication of Birch and Belmont's test, one used tape recorded auditory stimuli, and one required matching a visual light pattern and a printed dot pattern. The intercorrelations among these three tests were relatively high and ranged from .54 to .56.

The authors reported that neither the Birch and Belmont test nor the visual to visual type test contributed significantly with mental age in multiple regression equations. The tape recorded auditory test did account for 23 per cent of the variance in multiple regression with mental age in predicting reading scores and was a significant predictor of the reading scores at the .05 level.

Sterritt and Rudnick's conclusions were that the ability to equate temporal and spatial patterns within the visual modality could not differentiate good from poor readers at the fourth grade level. The test results could be interpreted to mean that integration within the auditory modality was a critical function of reading. An alternate explanation for the significant predictive ability found for this test was that the interpretation of the auditory pattern itself might be the important function being measured.

Beery (1967) used three measures of integration in her recent study. One task was devised using Birch and Belmont's ten items, another included these ten items with an additional ten items, and a third was a measure of visual-auditory integration where the visual standard was presented first and the child selected between two auditory choices. Auditory patterns for these tests were pre-recorded, which undoubtedly provided a more adequate auditory stimulus pattern than pencil taps.

Using 15 matched pairs of average and retarded readers, Beery found that the disabled readers were significantly less able to make equivalency judgments between auditory and visual stimuli. Neither the length of the test used nor the type of standard employed (auditory or visual) was significantly different in distinguishing between these good and poor readers. Integration ability was held to be an important function and one worthy of further exploration.

Rudnick and Sterritt (1967) reported on a further study using the three tests described above in Sterritt and Rudnick (1966). In this new study, 36 third grade boys were administered the three perceptual tasks, an IQ test, and a reading achievement test.

Intercorrelations among the three perceptual tests ranged from .34 to .52. In multiple regression equations, both of the Rudnick and Sterritt tests were significant predictors of reading achievement with mental age. Another conclusion drawn from this study was that in predicting reading ability, perceptual abilities were more important at younger age levels and IQ was of increasing importance at higher grade levels.

Ford (1967) explored AVI and tactual-visual (TV) integration in 121 boys. AVI in this study was measured in a different procedure from the measurement in the other studies reviewed. After the auditory standard was presented, the four visual choices were presented sequentially. The children had to decide whether each choice matched the standard. The TV test required the child to match a standard, which was out of sight but could be touched, with the correct visual representation for it.

The correlation of .17 between AVI and TV was small, and the correlations between IQ and AVI (.34) and TV (.02) were quite low. Partial correlations disclosed quite low relationships between AVI and reading with the IQ held constant. This was interpreted to indicate that both IQ and AVI were measuring the same factors. AVI also correlated .03 with Digit Span from the <u>WISC</u>, which indicated that auditory memory was not a function being measured by AVI.

The preceding literature has pointed out a certain amount of controversy as to the importance of integration tasks to reading ability, to what is being measured in such tests, and to the construction and reliability of the tests being used to measure integration.

To date, there is no firm evidence that the ability to make integration judgments between the auditory and visual modalities is important to reading. The evidence available does indicate this possibility, and further research into intersensory matching ability is warranted.

In order to pursue this topic, tests need to be constructed that will measure integration abilities accurately and reliably. Most previous tests have been exceedingly short and have offered no evidence of reliability. Care needs to be taken that auditory stimuli are accurately and consistently presented, since this is a weakness in some studies.

Little developmental data is currently available on integration abilities. A study would aid further research if it answered questions concerning developmental growth trends in integration by age, mental ability, and reading performance.

The Measurement of Memory Span

One of the widely researched topics in education and psychology has been the study of memory span, or short term memory. Studies of this ability date back to the 1800's, and current research still reports numerous studies. Two of the investigated aspects of memory span have been the method of scoring tests of memory span and the differences in the memory span for different types of material. This section will deal with the literature on these two topics.

Guilford and Dallenbach (1925) reviewed the previous research on memory span and reported that there were 16 different methods of evaluating raw score responses, 9 methods of weighting raw scores, and 2 methods of using correlations based on unit place values, that had been used up to that time. In this article Guilford and Dallenbach proposed yet another method. This article points out the lack of agreement among researchers as to the best method of measuring the memory span.

Three methods of scoring both the auditory and visual memory span tests were used by Rizzo (1939): gross span score, which was the number of letters reported that were present in the standard; accuracy of placement, or the number of letters correctly placed as they had been in the original stimulus; and the range score, the widest range over which letters in a series were correctly reported, even though some of the letters might be missing. Split-half reliability coefficients were reported for the three scoring methods. All three methods produced reliable measures, but the gross span method was most reliable.

Brenner (1940) used a per cent of correct series method in scoring his memory span tests. Ten tries at each series length were given, and each correct try at a series length was given .1 of a point. Brenner reported that this method was capable of distinguishing between subjects, and he considered that was the factor which determined whether a method of scoring was adequate.

Studies of memory span have also used different types of materials in the tests of memory span. Digits are the most common type of material used in such tests but other types of tests have been constructed.

Anderson (1939) used speech sounds in his study of the auditory memory span. His conclusion was that a test using vowel sounds was superior to a test containing consonant sounds. Both of these tests produced lower norms than tests of digits usually give. Anderson commented that the vowel test was superior to the consonant or digit type test because vowel sounds were more difficult to visualize. However, tests using vowel sounds may add auditory discrimination tasks to a test which is supposed to be measuring only memory.

Brenner (1940) constructed 17 different tests of memory span using different materials. He concluded that digits were the easiest material to remember, followed by consonants, colors, concrete words, geometrical designs, abstract words, paired associates, nonsense syllables, memory for commissions, and sentences. A factorial analysis yielded several factors, but one large common factor was identified as memory span.

In a study of 51 retarded male readers, Stauffer (1947) used memory span tests from the Detroit Tests of Learning Aptitude. These tests employ a variety of materials to measure memory span, including unrelated words, visual objects, related syllables, letters, and oral directions. Stauffer found that these memory tests produced different results with disabled and normal readers. He reported that retarded readers achieved significantly higher scores on tests using non-verbal materials presented visually than on verbal tests of auditory memory. Retarded readers had higher scores on related materials than on unrelated materials in tests of auditory memory.

Raymond (1955) found that for reading achievers: (1) a visual presentation was significantly easier than an auditory one; (2) in tests using an auditory presentation, related items were significantly easier than nonrelated items; and (3) in a test using digits, a visual presentation was superior to an auditory presentation.

Sandstedt (1964) confirmed Stauffer's finding that retarded readers were more successful with a visual test of unrelated items than with an auditory test of unrelated words.

The above studies indicate that different materials and methods of presentation produce variations in the length of memory span. This was the conclusion of Blankenship (1938) in his review of the literature on memory span.

Since there are many methods of scoring memory span tests and no generally accepted best method, the simple scoring method used by

Brenner (1940) will be adopted for use in this study. This method counts all correct series, and Brenner reported that it was capable of distinguishing between individuals.

While some investigators have reported differences in memory span based on the type of materials used, there is little evidence to suggest one material is better than another. Therefore, digits were selected to be the material for the auditory memory test. It is the most common type of material used in auditory memory span tests and will make the results of this study more comparable to other studies. Consonant letters were selected for use in the visual memory test because they will make this test more closely related to reading skills.

Auditory Memory

Deficiencies in auditory memory have often been linked to reading disability in the great mass of literature available on memory span. Saunders (1931) reported that the retarded readers with whom she worked had deficiencies in auditory memory span. She concluded that these children had a learning handicap but were not retarded in mental ability.

Bond (1935) included two measures of auditory memory in his study of the relationships of auditory abilities in poor readers. He concluded that "probably" auditory memory was an important factor in learning to read by a visual approach but was less important in a phonetic approach. This conclusion, however, was based on a tendency that was not statistically significant. Auditory memory as measured by tests using digits and nonsense syllables did not significantly discriminate between poor readers and their normal reading controls.

Rizzo (1939) compared poor and good readers on auditory memory span and found that mean memory span scores of these two groups were not significantly different, but all of the differences favored the good reader group. Differences favoring good readers were larger at the lower grade levels than at the upper grade levels. Several reading disability cases in this study had extremely low memory spans.

In a massive correlational analysis of 43 auditory abilities and silent and oral reading measures, Ewers (1950) found that a test of "auditory fusion memory span", which was very similar to Rizzo's auditory memory test, had a very low correlation with silent reading (.12) but a moderately high correlation with the oral reading test (.42).

Reynolds (1953) studied 138 fourth grade children in four schools to determine relationships between eight auditory factors and silent reading performance. These children were unselected and included all types of children with possible hearing loss or reading disability. Since there appeared to be differences between the four schools, he analyzed the data from these schools separately.

Coefficients of correlation between a group adapted test of memory for digits and the silent reading criterion were .21, .46, .37, and .61 in the children from these four schools. The last three coefficients were significantly different from zero at the .01 probability level. However, partial correlational analysis did not indicate that the adding of measures of auditory ability, including auditory memory, to mental age increased the predictive value of the mental test in estimating silent reading ability.

Raymond (1955), in comparing 50 reading achievers to 50 underachievers of the same chronological age, found that auditory memory span tests did discriminate between these two groups of children.

Rose (1958) checked the test results of 113 remedial reading cases on the Stanford-Binet, Form L. She concluded that the tests of auditory memory contained in this intelligence test were extremely difficult for the reading disability cases in her study. Although Rose felt that there was no proof of casualty of reading problems with a short memory span, she felt that auditory memory span problems were symptomatic of reading disability.

Other researchers have used the Wechsler Intelligence Scales in separating retarded from normal readers and in establishing predictive relationships between scatter scores on these tests and reading disability.

Neville (1967) reviewed twelve studies which used the WISC to establish distinctive scatter-patterns for both disabled and normal readers. He reported that five of these studies found Digit Span, an auditory memory test on the WISC, to be a significantly low score in the disabled readers' profiles. Seven of the studies reported that there were no significant differences between the Digit Span scores of disabled and normal readers.

Sawyer (1965) dropped the use of Digit Span from a set of sub-tests in the WISC used to predict reading disability. She found that the Digit Span had a low reliability and contributed less to prediction than other sub-tests from the WISC.

The review of literature on the importance of the auditory memory span to reading ability is quite mixed. There is as much evidence to disprove its usefulness as there is to support its use in diagnosing reading problems. Few investigators, however, have used oral reading criteria in their studies, and this study will provide information concerning the relationships between auditory memory and oral reading.

Visual Memory

Most of the past research into visual memory has used flashed tachistoscopic presentations of digits, letters, or words in examinations of the amount of information that can be processed by the eyes and brain. A great deal of this research has experimented with small numbers of subjects (less than 10) and has not concerned itself with the relationships between visual memory and reading abilities. The following studies provide a brief summary of this research on visual memory that used tachistoscopic presentations, as well as the studies that have more pertinence to this investigation.

In a previously quoted study, Rizzo (1939) studied visual memory span with two types of presentation of nine-letter nonsense words. One of these methods was a flashed tachistoscopic presentation and the other was a serial presentation of units of letters. He found that the tachistoscopic presentation showed growth tendencies from left to right, while the serial presentation produced growth inward from both extremes.

Rizzo found that, as with the auditory memory span, correlations were not sufficiently large to predict reading achievement from the visual memory scores. There was a positive but nonsignificant relationship between these factors.

Rudisill (1956) reported that span and accuracy of flashed phrases were more highly related to reading than a flashed digit test. Her results, though, must be interpreted with caution. Intelligence was not controlled in this study and there was a two-year difference between the mental ages of good and poor readers, favoring the good readers. Her conclusion that there is a relationship between visual memory span and reading may be merely a reflection of the high correlations usually reported between memory span and intelligence.

Raymond (1955) reported that reading achievers made significantly higher scores on visual memory-span tests than on auditory memory tests, and the visual memory-span tests discriminated between good and poor readers.

Sperling (1960) studied various aspects of visual memory for tachistoscopically presented digits and letters. He concluded that there is an individual constancy of memory span when measured in one way, regardless of the spatial arrangement or mixture of letters and digits used.

Increasing the amount of exposure time for the subjects did not result in an increase in the number of correctly reported letters. This led Sperling to conclude that there is a maximum memory span within the individual, and that there is more information available to subjects than they can report, or utilize.

Alwitt (1963) examined nonreaders to determine if their relatively poor visual memory was a function of a more rapid decay of immediate memory traces. From her study of 19 pairs of reading disability cases and good readers matched on chronological age, she concluded that there was no significant difference between the rate of decay of the memory trace in the two groups. However, there was evidence that memory span for digits increased more rapidly by chronological age for good readers than for poor readers, on the basis of the nineteen pairs studied.

Alwitt offered two hypotheses to explain this finding and felt that either was a tenable possibility:

1. Reading may train an individual to perceive and process bigger chunks of material and thus develops memory span.

2. Or, a low span of visual memory may be part of the causational factors associated with reading disability.

In a group of retarded readers, Sandstedt (1964) reported that total visual memory-span scores were higher than total auditory memory-span scores. She noted a high correlation between memory-span factors and IQ, and a memory-span battery was suggested as being of diagnostic value in the analysis of reading difficulty.

Marchbanks and Levin (1965) used a test of delayed visual memory to determine which clues children used in recognizing words. The technique employed words on cards which were shown to the child and then removed from sight. The child had to pick this standard from a list made up completely of distractors. Since the child was forced to make an error on every test item, these errors showed which clues these children used in recognizing words.

The resulting errors made by the kindergarten children showed that initial letters were the most important clues used in word recognition, and final letters were the second most important clue used. The shape or form (configuration) of the words was the least used clue in word recognition by these kindergarten children.

The literature reviewed in this section points out that most investigators have found visual memory to be significantly related to reading achievement. Two investigators reported that visual memory span was related to the amount of information that could be utilized by the individual and not to the amount of information that was available. This was true for disabled readers as well as for normal achievers.

The individual letters of words have been pointed out as being the most used clues in word recognition for kindergarten children, and the use of letters in a test of visual memory would seem to be indicated.

Summary

The reviewed literature has pointed out an amount of controversy over the importance of integration tests to reading ability. Some evidence has been found to indicate that integration abilities are not closely related to memory span factors. Most investigators of integration to date have not supplied reliability data for their instruments. Further research into integration abilities seems warranted to ascertain the nature of growth in integration abilities in elementary school children and the importance of this growth to reading performance.

In studying the literature on the measurement of memory span and the type of material that should be used in such tests, it was found that researchers have been of divided opinions on both topics. There were many ways to score tests of memory span and many types of materials used to construct these tests. The evidence did not indicate that any scoring method was a superior one. The use of different types of materials in tests of memory span produces different span scores, but digits were the most commonly used material for measurement of the auditory memory span.

While there were numerous studies dealing with the auditory memory span, further research into this ability can be justified. The conflicting reports in the literature on the importance of the auditory memory span to reading and the lack of studies which have investigated auditory memory and integration abilities make further research desirable.

Few studies have concerned themselves with the perception and memory of letter-constructed nonsense words in a manner which approaches the demand during reading. Marchbanks and Levin (1965) noted that the use of lighted fields in tachistoscopic presentations of digits or letters produces after-image effects and other deviations from normal reading. Thus, a visual memory test employing letters should add to research on visual memory.

Also, the relationships between visual memory and integration have yet to be explored fully, and the inclusion of a test of visual memory in a study seems justified from this standpoint alone.

The review of the literature has pointed out the need in this investigation to construct four tests which can be used to test the hypotheses generated in this study. The implications from this past research will be used in Chapter III to design the study and to create four suitable test instruments with reliability data obtained from the study.

CHAPTER III

METHODOLOGY AND DESIGN

In keeping with the findings from the review of literature, the study was designed to answer the questions generated in the statement of the problem. This design and the methodology used to test the study's hypotheses are described in this chapter and are organized into these sections: (1) the population and sample of the study; (2) the testing procedures; (3) the standardized test instruments; (4) the four constructed tests; and (5) the statistical techniques. These five sections are followed by a brief summary of this chapter.

The Population and Sample of the Study

The population for this study was the elementary school children in a north central Oklahoma town of 2,300 people. This population was selected because of its convenience and the willingness of the school officials to permit this rather lengthy study, rather than on an attempt to make the population more representative of a larger population. Thus, the population for this study is a fortuitous or convenient one.

According to school records, the elementary school for this study has a population made up of 78 per cent Caucasian, 20 per cent American Indian, and 2 per cent Negro elements. The large percentage of American Indians and the small percentage of Negroes make the population of this school atypical of the population of elementary school children in the United States.

Children within this population were randomly selected for the sample on a stratified basis, with the following steps being followed:

1. The California Test of Mental Maturity, administered in January, 1969, was used as a screening instrument. Only those children with IQ scores between 85 and 115 were included in a pool of eligible names.

2. A table of random numbers was then used to select 15 boys and 15 girls at each grade level.

3. Letters requesting permission for the testing were sent home with the selected children. For the two children whose parents refused to grant permission, replacement names were drawn from the remaining pool of names at the proper grade level.

Testing Procedures

The main testing for this study occurred during March and April of 1969. Each child was administered both an individual session of testing that included the Gilmore Oral Reading Test, a test of auditory memory, and a test of visual memory; and a group session that included the two tests of integration abilities. Since the individual testing sessions required nearly two full months, equal proportions of children were tested from each of the six grades during each week of the study to help gain a more even measurement of the abilities throughout the grades.

The individual testing was completed in a well lighted and ventilated room that was quiet and contained few distracting objects.

The children were informed in advance before they were taken from their classrooms, and a short period for establishing rapport was included for each subject. To establish this rapport, the examiner conversed with each subject about the school or any topic of interest. The children were told not to worry about their test score performance because no one would ever know these results except the examiner, and they were just helping him to find out how children learned to read. No rewards of any kind were given to the subjects.

The group testing followed the individual testing of all the sample and included both the test of auditory-visual integration and the test of visual-auditory integration. These two tests together required approximately 27 minutes to complete, including all test directions. The children were tested in groups of 8 to 12 taken from the same classroom.

The testing was done in vacant classrooms, so distracting influences were more difficult to control than in the individual sessions. However, the directions and auditory stimuli for these tests were pre-recorded, and the pacing of the directions and test items required concentrated responsiveness. The examiner moved around the group during the sample test items to be sure the directions were understood and followed. Once the test items began, the examiner moved to the front of the room and no further help was given any subject. Further directions for these two tests are included in Appendix A.

Standardized Testing Instruments

The California Test of Mental Maturity (California Test Bureau, 1963) was used as both the screening instrument for the sample selection and the source for mental age scores. This measure was used in this study because it had recently been given to all of the elementary school children in the selected school by the school's counselor. The date of administration of this test was January, 1969, and the Test Bureau of Oklahoma State University scored the tests by machine.

The score for total IQ, which weights both verbal and nonverbal test items into its scoring procedure, was used since it provides the best estimate of intelligence in such group tests.

The Gilmore Oral Reading Test, Form A (Harcourt, Brace and World, Inc., 1951) was selected to provide two measures of reading performance, oral accuracy and comprehension. In this test, children read progressively more difficult passages aloud, and the examiner records the number and type of errors made. Five questions, covering literal comprehension of the passage, are asked the child following each passage read.

In administering this test, a basal level is first established at the passage where no more than two accuracy errors have been made. The child then reads more difficult passages until a ceiling level is reached at the passage where ten or more errors of accuracy have been made. Accuracy errors are all deviations from a perfect oral reading of the passages.

On each passage below the ceiling level, an accuracy score is determined by subtracting the number of errors made from ten, which is the point score for any passages read perfectly or below the basal level. The raw score for oral accuracy is the sum of all of the scores for passages read or below the basal.

In determining the oral comprehension score, the number of questions answered correctly on each passage read was summed and added to a credit for the passages below the basal level. This credit follows the procedure outlined in the manual for this test which credits one more question as correct than was scored correct on the preceding passage, up to the maximum of five points. The raw score for oral comprehension is the sum of all of the comprehension questions answered correctly plus the credit for questions below the basal.

This scoring procedure is a modification of the manual directions, since in this study no credit for comprehension was given for passages above the ceiling level. In the manual procedure, credit is given for passages above the ceiling level by scoring as correct a number one less than the credit on the preceding passage. For example, a child who reached his ceiling level at the fifth passage and answered all five questions correctly, receives four points for passage six, three points for passage seven, two points for passage eight, and one point for passage nine--a total of ten extra points for passages not read.

Another child, who is slightly better at oral reading, may also score five correct answers on passage five, but since this was not a ceiling level on oral accuracy, he reads passage six. If the child experiences extreme difficulty in reading this passage, his comprehension score on this passage may be zero questions correct. In this case, he receives no extra points and is actually penalized for being a better reader.

A more extreme example than this of the problems in the manual's scoring procedure for comprehension is the first grade child who has a great amount of trouble orally reading the first passage. This level could be both the basal level, no passages below it, and the ceiling level where ten or more accuracy errors were made. However, if the child answered all five questions correctly on passage one, he would be entitled to ten more points when he really could not read passage one satisfactorily.

As can be readily seen from these two examples, such an arbitrary scoring procedure can lead to extreme and erroneous fluctuations in the comprehension scores for different children. Since this observation was made by the examiner after a large amount of the testing had been completed for this study, an alternate scoring method for comprehension was considered essential. Thus, the method used in this study was devised. This method counts as points toward comprehension only those passages which have been read or are below the basal level.

This modified procedure has the advantage of tying the comprehension score directly to the oral accuracy, as it assumes that no comprehension is possible for subjects on passages above their ceiling level. This assumption is probably incorrect for many children, which introduces a source of possible error. However, the main purpose of this study was to examine the effects of certain variables on oral reading performance, and this scoring procedure seems most logical and should introduce less error than the manual's scoring method.

It should be kept in mind that the adopted scoring procedure tends to cause the oral comprehension score to become a close function of the oral accuracy score, and the resulting high correlation of .89 between these two reading criteria should be interpreted in this light.

The Four Constructed Tests

The four abilities measured in this study by the constructed tests have all been previously examined by other investigators. While there are numerous tests available from these past studies, the tests used have been attempts to improve on the available instruments. Most of the tests that are currently available to test these four abilities lack reliability data or a broad enough sampling of items to test the range of six grade levels included in this study.

Coefficients of reliability were computed for the four tests constructed; and Chapter IV contains the reliability data based on the total sample in this study, and Appendix D lists the coefficients of reliability for these tests by grade level. The following description of the test instruments and procedures explains the construction and scoring of these measures.

Auditory Memory

In this test sequences of digits were read to the subject at the rate of two per second. The child was instructed to repeat the series of digits after the examiner. Four sets of digits of each length were read to the child, and the series were of two to seven digits in length. The younger children, first and second graders, were started at the three digit series, and the older children were started at the four digit series. All four tries of a series had to be repeated exactly before a basal level was assumed, and the child had to miss all four tries of a series before a ceiling level was assumed.

Subjects were credited with .25 points for each series of digits repeated correctly, or assumed to be correct because they were below the basal. For example, if the child repeated correctly all four tries of the three digit series, three of the four digit series, and one of the five digit series, his score would be 4.00. The child would have received 3.00 for getting all four of the three digit series correct, plus .75 for the three series of four digit length, and plus .25 for the one set of the five digit series which was correct. Appendix A contains the digit series used in this study.

Visual Memory

This test of Visual Memory required the child to recognize, from among a group of five distractors, the correct letter sequence that had been originally presented. The stimulus items for this test were presented in a hand operated device constructed for this study. The stimuli presented were of standard elite type on a white background. A red underline marked an opening on the device through which the series of letters were presented.

An answer sheet containing the stimulus items and the distractors was placed in front of the subject with a place marker underlining the test item. The subject was presented the stimulus in the device for a maximum time of two seconds. The subject was instructed to find the group of letters that were exactly the same as the stimulus presented. Subjects could look at the stimulus only once, and they marked their answers on the sheet by drawing a mark through the correct response.

The maximum time of two seconds for presentation of the stimulus was probably ample, so that speed of perception was not an important factor in this test. Appendix A contains the 38 test items with the correct stimuli answers underlined.

Auditory-Visual Integration

The test used to measure AVI ability was designed to overcome some of the possible weaknesses in the test of AVI as reported by Birch and Belmont (1965). Birch and Belmont auditorily presented a series of pencil taps with varying pauses between the taps. Subjects were to equate these taps with visual representations of these sounds, which were dots printed on cards with varying spaces between them. For example, if two taps were heard together with a pause followed by one more tap, the subject had to identify that pattern by picking a series of dots that resembled it, (.. .).

However, the test used by Birch and Belmont had only ten items. It is possible that because this test was short it failed to measure small differences in ability. Also, since the average of correct responses for second graders was 7.9, this test probably failed to measure the AVI ability of older children.

In the test of AVI, subjects equated sequences of dots, dashes, and spaces, which were presented auditorily, to visual representations of these sound sequences by selecting the correct visual pattern from among a choice of three patterns. For example, a short sound followed by a long sound and a pause followed by a long sound would have a visual pattern of (. _ _).

To create the auditory patterns and provide some standardization of administration, the auditory stimuli were generated by a puretone audiometer and tape recorded with the accompanying directions. The generated pure tones were at 1000 cycles per second and were fed directly into a Wollensak Tape Recorder to avoid background noise. Recorded dots were of approximately one-fifth second in duration, dashes were about one second in length, short pauses were approximately one-fifth second, and long pauses were about one second in length.

The 24-item test constructed to measure AVI in this study was easily constructed following this procedure. The visual representations used in this test are included in Appendix A with the stimulus items underlined.

Visual-Auditory Integration

This test requires the equating of visually presented and spatially distributed sequences of dots and dashes with auditorily presented and temporally distributed sequences of sounds of short or long duration. This test was created by using the same procedure for auditory stimuli as was used above.

In this test, the children were shown a visual pattern of dots, dashes and spaces for two seconds. This was followed by an auditory pattern of short or long sounds and pauses. The children listened to the pattern and decided whether the sound pattern was the same or different from the visual pattern. An answer sheet was provided for recording same or different by placing a mark in the appropriate box.

Since this test was administered to a group at one time, the visual patterns were presented on large white cards measuring six by eight inches. The dots were approximately five-sixteenth inches in diameter and the dashes were one and one-half inches long and one-fourth inch thick. Short spaces between stimuli were three-fourth inches and long spaces were two and one-half inches. Appendix A contains a reduced version of the visual stimuli and a visual representation of the auditory patterns that were presented.

Statistical Techniques Used in the Treatment of the Data

Reliability of the Constructed Tests

On all four of the investigator constructed test instruments (AVI, VAI, Auditory Memory, and Visual Memory) coefficients of reliability were computed using the Spearman-Brown modified formula for comparison of scores on the odd and even test items. In this procedure, a coefficient of correlation is computed between the odd and even items of the test which yields a coefficient of reliability for two tests that are one-half the length of the original test. The following Spearman-Brown formula corrects for the length of the actual test:

$$r_1 = \frac{2\, r_{oe}}{1 + r_{oe}}$$

Where r_1 = the coefficient of reliability of the test

r_{oe} = the coefficient of correlation between odd and even items

The standard error of the test scores, or the standard error of measurement, was also computed using the following formula:

$$\sigma \text{ score} = \sigma t\sqrt{1 - r_1}$$

Where σ score = standard error of measurement

σ t = standard deviation of test scores in the group which the coefficient of reliability was computed

r_1 = the coefficient of reliability of the test

Analysis of Sub-Groups

To determine whether there were significant differences between sample sub-groups in testing hypotheses one and two, the IBM 360/Model

50 computer at Oklahoma State University was used with the Analysis of Variance for One-Way Design program, BMD01V, version of June 15, 1966, prepared by the Health Sciences Computing Facility of the University of California--Los Angeles.

The analysis of the variance investigated the possibility that significant differences existed among the grade levels on IQ scores or between the scores of boys and girls at each grade level on IQ or oral accuracy.

Examination of Growth Curves

To test hypotheses three and four, the scores from the constructed tests were examined in different ways. The children from the sample were separated into grade level groups on their age grades and on their mental grades; and they were separated into performance intervals on their oral accuracy and oral comprehension scores. In each of these four divisions of the children, the mean scores of all children within intervals were computed for the four constructed tests. This allowed plotting graphs for each of the constructed tests in four ways: by age grade, by mental grade, by oral accuracy, and by oral comprehension.

Analysis of Sex-Based Differences

Using the same computer and program listed above for the analysis of sub-groups, an analysis of variance was performed on the scores of the four constructed instruments to test the fifth hypothesis of this study. This analysis of variance determined whether there were differences in the performances of the boys and girls at each grade level on the four constructed tests.

Correlation Analysis of Variables

To determine whether there were significant interrelationships between the two integration tests, and between the integration tests and auditory memory, visual memory, age grade, or mental grade, zero order correlations were computed between these variables.

To test the sixth hypothesis of this study, the correlations which were computed were analyzed to determine whether they were significantly different from zero. In addition, coefficients of determination were computed by squaring the correlations, which gives the proportion of the variance between two variables that is explained by the coefficient of correlation.

Factorial Analysis

The children's scores on the tests of oral accuracy, oral comprehension, VAI, AVI, auditory memory and visual memory were examined by factorial analysis to test the seventh hypothesis. These data were analyzed by a program for the IBM 360/Model 50 computer at the Oklahoma State University Computer Center, which samples the main program for a principal component solution, performs a varimax rotation of a factor matrix, and prints the results.

Regression Analysis

To test hypotheses eight and nine, the Oklahoma State University computer program of April, 1969, for multiple linear regression was used on the data from this study. This program is a version of the regression program contained in IBM's system/360 scientific subroutines package.

Several regression equations were constructed with this program between two dependent variables, oral accuracy and oral comprehension, and the independent variables: auditory memory, visual memory, AVI, VAI, and mental grade.

The program used provides these results for each regression equation: the regression coefficient for each independent variable, a computed t value which gives the level of significance from zero of each regression coefficient (Edwards, 1967, pages 252-253) the intercept value for each equation, the multiple correlation of the independent variables in predicting the dependent variable, and the F ratio from the analysis of variance for regression.

Summary

This chapter has outlined the specific steps used in the selection of the sample and has explained the test instruments employed to gather the data necessary for testing the hypotheses. In addition, the statistical techniques and procedures used in the treatment of the data have been explained to facilitate the presentation of the results of the study in Chapter IV.

CHAPTER IV

STATISTICAL ANALYSES

This chapter presents and discusses in some detail the results of the statistical treatment of the data collected in this study to test certain hypotheses. For convenience in presentation, this chapter will be divided into seven sections followed by a chapter summary.

The first section of this chapter covers the reliability data gathered from this study on four tests that were constructed. This treatment of the data shows the amount of confidence that can be placed in these tests to consistently measure auditory memory, visual memory, visual-auditory integration, and auditory-visual integration.

A section on the analysis of sub-groups presents data concerning any differences that were found in the sample among grade levels or between the two sexes. The statistical procedures used will test the first two hypotheses of this study that there were no significant differences among the performances of the children at different grade levels on the intelligence test, and no significant differences between the performance of the boys and girls at each grade level on IQ or oral accuracy in reading. These analyses will aid in interpreting growth curves in the next section of this chapter.

Sixteen graphs displaying the developmental growth in auditory memory, visual memory, VAI, and AVI, as tested in this study, make up a section of this chapter that will test the third and fourth hypotheses.

An analysis of these graphs will determine whether the growth in abilities is most rapid in the initial segment of these curves and whether these abilities tend to reach a plateau level within the elementary grades.

The next section of this chapter tests the fifth hypothesis. This hypothesis examines the differences between the mean scores of boys and girls at each grade on the four constructed tests. If there were indications of sex-based superiority on these four tests, implications would be raised for further use of these tests.

The correlation matrix for the variables used in this study is examined in a section to test the sixth hypothesis. This presentation explores the interrelationships among variables to determine whether these correlations are statistically significant.

A factor analysis of the variables in this study is described in the next section of this chapter which explores the factor structure underlying the tests used. This statistical treatment of the data tests the seventh hypothesis that there is no one factor which accounts for most of the variance in these tests.

The last main section of this chapter tests the eighth and ninth hypotheses. The results of multiple regression equations are described which tests the effectiveness of these four variables in estimating the two measures of oral reading.

Reliability of the Four Constructed Tests

One approach to estimating the reliability of a test, when alternate forms are not available, is to split the test into two halves of odd and even items. The subjects' scores on these two halves are correlated and the Spearman-Brown modified formula is used to correct this correlation. Table I reports the coefficients of correlation between the split halves, the coefficients of reliability after the correction formula has been applied, and the standard errors of measurement for the four constructed tests. Appendix D contains a breakdown of this data for each of the grade levels.

As can be seen from Table I, the coefficients of correlation between the split halves of these four tests were relatively high, ranging from .77 to .89. The resulting coefficients of reliability cluster from .87 to .94. Since reliability coefficients as large as .90 are considered to be significantly high (Wert, Neidt, and Ahmann, 1954, page 341), only the test of auditory memory is of questionable reliability, and the coefficient of reliability for this test is quite close to the acceptable level. Thus, all four tests appear to be statistically reliable, and the results from these tests can be used in further analyses.

Analysis of Sub-Groups

Before considering the developmental growth of the constructs tested in this study, it was necessary to analyze the sample sub-groups to determine whether sampling errors existed that might bias other results. The analyses performed investigated possible differences among the grade levels on IQ and between the sexes at each grade level on IQ and oral accuracy.

An analysis of variance for one-way design was performed on the IQ scores of the total sample to test the first hypothesis that was stated:

TABLE I

CORRELATIONS BETWEEN ODD AND EVEN ITEMS, COEFFICIENTS OF RELIABILITY AND STANDARD ERRORS OF THE TESTS OF AUDITORY MEMORY, VISUAL MEMORY, AVI AND VAI

	Correlations Odd-Even	Coefficients of Reliability	Standard Errors
AM	0.77	0.87	1.95
VM	0.86	0.92	1.78
AVI	0.86	0.92	1.84
VAI	0.87	0.94	1.72

There are no significant differences among the mean IQ scores of the grade levels in this study.

Table II reports on the analysis of variance that was performed to test the hypothesis. As can be seen, the critical F ratio is non-significant and there is evidence that the students in the six grades did not differ on the basis of the measured IQ scores.

To further examine the variances within the grades, an analysis of variance was performed to test the differences between the two sexes at each grade level on IQ scores and oral accuracy scores. The hypothesis tested was number two, which stated:

There are no significant differences between the mean IQ or oral accuracy scores of the boys and girls at each grade level in this study.

Table III reports the results of the analyses of variance for both IQ and oral accuracy between sexes. The critical F ratio for the difference between boys and girls on mean IQ scores at the sixth grade level is significant at the .01 level. Thus, the null hypothesis of no significant differences between sexes on IQ can be rejected at the sixth grade level, but it must be retained for the other five grades.

The analysis of variance to test the second hypothesis of no significant differences between the performances of boys and girls at each grade level on oral accuracy is also presented in Table III. There are two significant F ratios, one at second grade and one at fourth grade. Thus, the null hypothesis of no significant differences can be rejected at the .05 level in favor of the performance of the second grade girls and in favor of the fourth grade boys.

The three significant differences discovered between the sexes in the sample on IQ and oral accuracy scores will aid in the interpretation

TABLE II

ANALYSIS OF VARIANCE AMONG GRADES ON IQ SCORES

Source of Variation	Degrees of Freedom	Sum of Squares	Mean Squares	Critical F Ratio
Between Grades	5	336.9	67.4	1.3
Within Grades	174	9272.3		
Total	179	9609.2		

Critical F ratios are significant at the .05 level if the value exceeds 3.89.

TABLE III

SUMMARY OF THE ANALYSIS OF VARIANCE BETWEEN SEXES ON IQ SCORES AND ON ORAL ACCURACY

Grade	Critical F Ratios on IQ	Critical F Ratios on Accuracy
First.....	0.18	2.58
Second.....	0.08	6.96*
Third.....	0.02	0.82
Fourth....	1.85	7.01*
Fifth.....	2.43	2.10
Sixth.....	9.78**	0.06

*F ratios are significant at the .05 level with values greater than 4.20.

**F ratios are significant at the .01 level with values greater than 7.64.

of the analyses performed in the next two sections of this chapter. The next section examines the developmental growth curves for the four constructs of sub-abilities in reading that were tested in this study.

Developmental Characteristics

One of the simplest ways to examine developmental characteristics of constructs that have been tested is to plot growth curves for these abilities. Each of the four constructs tested in this study have been graphically plotted by mean raw score in four ways: by age grade, mental grade, oral accuracy, and oral comprehension.

Auditory Memory

Figure 1 shows the growth in auditory memory, as measured in this sample, by age grade. Age grade is a way of computing the grade a child should be in, on the basis of his chronological age. The computational method is to subtract five years from the child's attained age, which was figured to April 1, 1969, for all children in this sample.

After this computation, the children were grouped into seven age grade levels: 1.0-1.9, 2.0-2.9, 3.0-3.9, 4.0-4.9, 5.0-5.9, 6.0-6.9, and 7.0-7.9; and then the children's scores were averaged at each of these levels. Figure 1 shows that the growth curve for auditory memory is rather smooth and even throughout the first four age grade intervals. The uneven growth following the 5.0-5.9 interval is suggestive of a plateauing effect, but there is not enough evidence from this data to support the idea. Thus, a straight line is the best fit for this curve.

Figure 2 presents the growth curve of auditory memory by mental grade levels, determined by subtracting five years from the children's

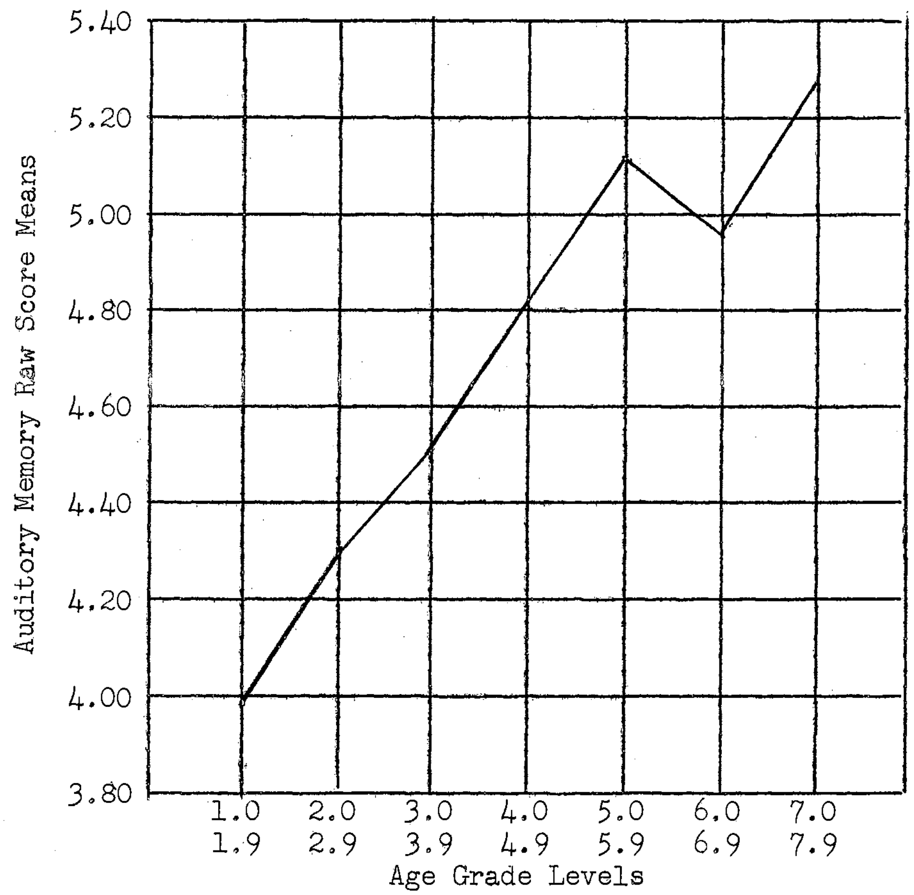

Figure 1. Developmental Growth Pattern for Auditory Memory by Age Grade

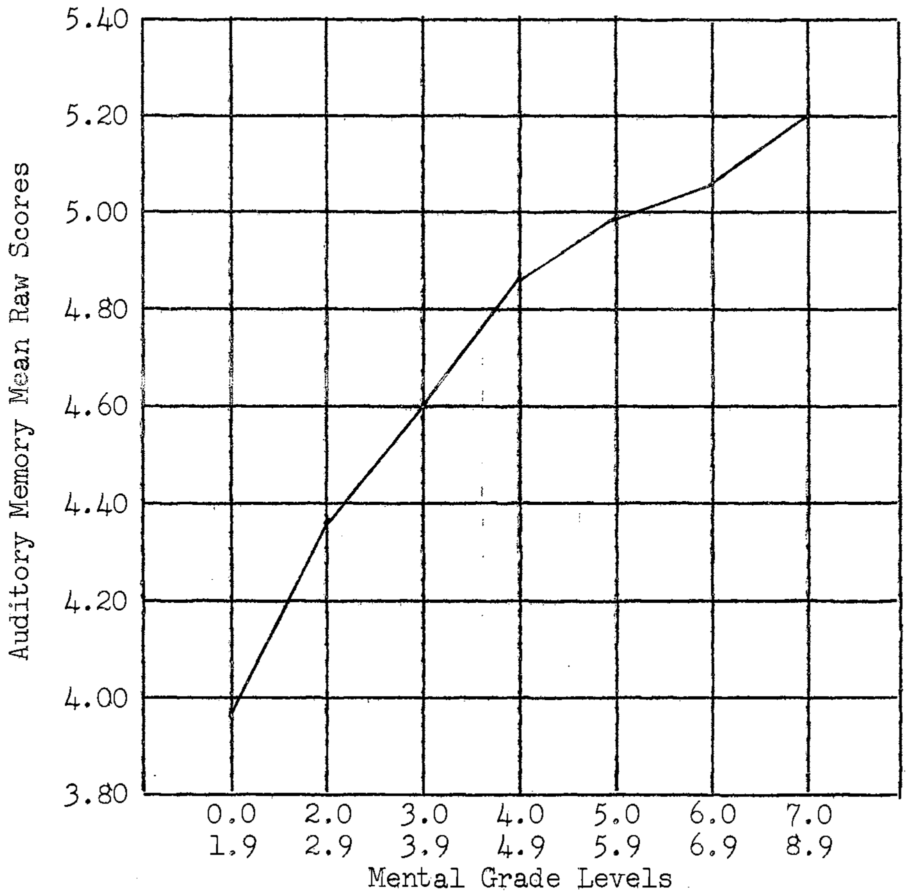

Figure 2. Developmental Growth Pattern for Auditory Memory by Mental Grade

mental ages as obtained from the California Test of Mental Maturity, total score. These scores were again calculated to April 1, 1969, and the children were placed in the appropriate mental grade category and the scores averaged. Since there were only two subjects with mental grades below 1.0, the first interval was extended to include them, and the last interval was extended to include nineteen children with mental ages above 7.0.

As can be observed in Figure 2, the growth curve for auditory memory is quite smooth and regular. This indicates that the test of auditory memory is producing increasingly higher mean scores at successively higher mental age levels.

Figure 3 displays the growth curve for auditory memory by oral accuracy raw score intervals. These oral accuracy intervals were set at ten points. Since the scores of only eighteen children were below fifteen points, these children were all grouped into the first interval. After this grouping of the children into intervals, their auditory memory scores were averaged at each interval to produce a mean raw score.

As can be seen from Figure 3, the relationship between increased performance on oral accuracy and auditory memory is a positive and fairly straight-line one throughout all of the accuracy intervals.

Figure 4 shows the growth pattern for auditory memory by oral comprehension intervals. Five point intervals were selected for grouping the children by comprehension, but larger intervals were necessary at the lowest and highest levels because so few subjects were clustered at these points.

The line of best fit for this curve of auditory memory by oral comprehension is a straight line. While the downward trend at the last

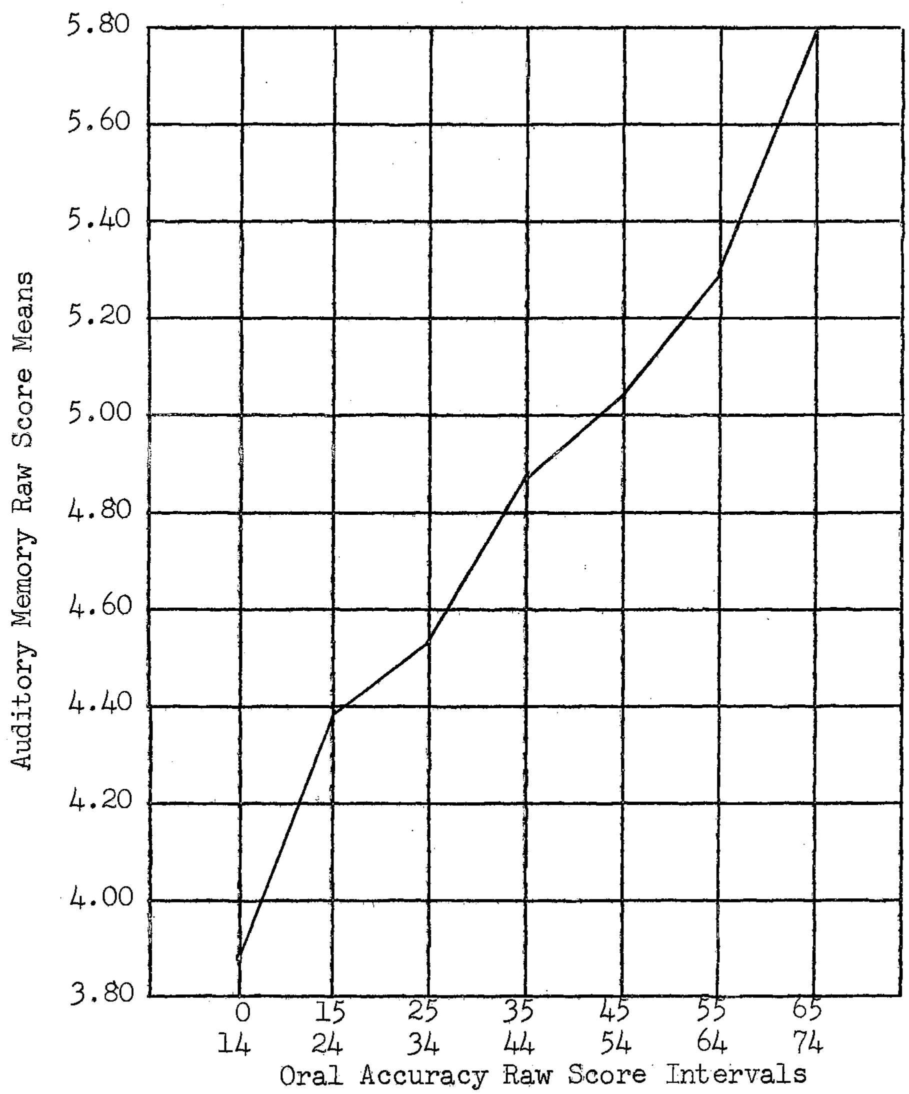

Figure 3. Developmental Growth Pattern for Auditory Memory by Oral Accuracy

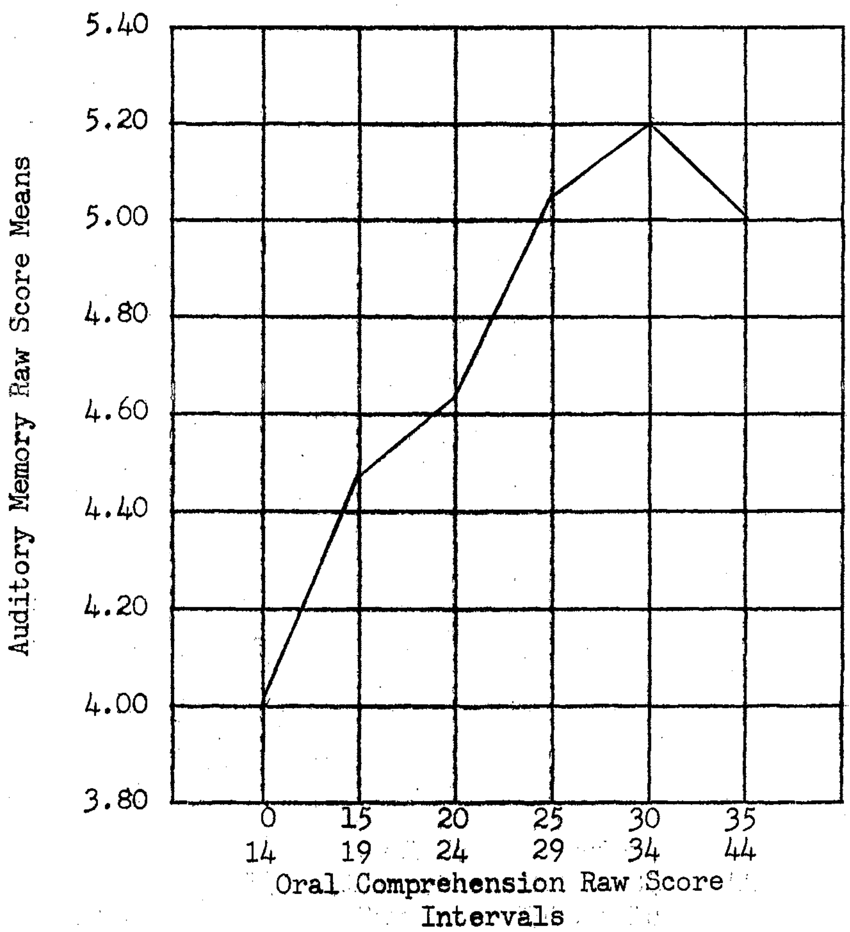

Figure 4. Developmental Growth Pattern for Auditory Memory by Oral Comprehension

interval is suggestive of a peaking effect, this may be merely the result of chance fluctuations, and it is difficult to assume a trend from one point on a curve. It is logical to assume from the rest of this curve that growth in auditory memory would increase if higher grade levels had been tested.

The four curves constructed to display growth trends in auditory memory have indicated that a straight line relationship exists between this factor and age grade, mental grade, oral accuracy, and oral comprehension.

Thus, hypotheses three and four cannot be rejected for the curves showing growth in auditory memory. These hypotheses were that there are no plateaus indicating a cessation of further growth in the developmental curves and there are no indications that growth in abilities is most rapid in the initial segment of these curves.

Visual Memory

Figures 5, 6, 7, and 8 display the measured growth in visual memory, as tested in this study, in the same four ways as the auditory memory factor was examined: by age grade, by mental grade, oral accuracy, and oral comprehension. Figure 5 shows the growth curve for visual memory by age grade.

This growth curve for visual memory in Figure 5, shows a consistent increase up through the 4.0-4.9 age grade interval, followed by a much slower and uneven growth. The best interpretation of this abrupt change in the developmental curve would be that this ability has reached a plateau by the 4.0-4.9 age grade level.

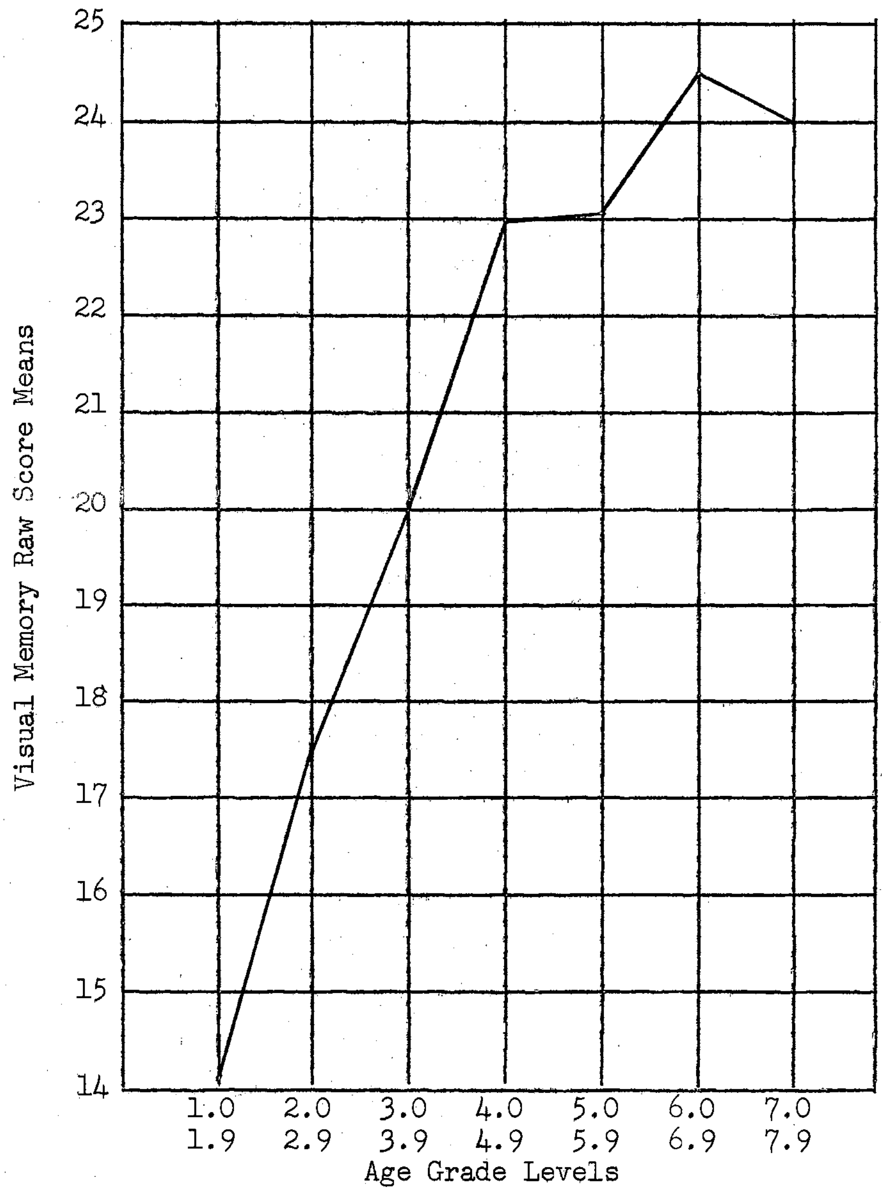

Figure 5. Developmental Growth Pattern for Visual Memory by Age Grade

The developmental pattern in Figure 6 by mental grade shows a steady growth in ability through the first few levels, followed by an irregular pattern during the last two levels, which suggests a plateau level has been reached.

Figure 7 displays the growth pattern by oral accuracy for visual memory. As can be observed from this curve, the pattern is fairly regular and consistent throughout the initial segment of the curve, followed by a fairly definite plateau level.

Figure 8 shows the developmental curve for visual memory by oral comprehension. As can be noted from this curve, growth in visual memory is fairly rapid through the first three intervals, but a definite plateau level for this ability is reached in the final curve segment. The curve for visual memory in Figure 8 is remarkably like the three preceding graphs, and the growth indications for this ability are consistent in all four presentations.

Therefore, hypotheses three and four can be rejected for the curves displaying visual memory growth. These hypotheses were that growth in ability did not reach a plateau indicating cessation of further growth and that growth in the abilities was most rapid in the initial segment of the curve. For visual memory, as tested in this study, growth is most rapid in the beginning section of the curves and reaches a plateau level where little further increase is indicated.

Auditory-Visual Integration

Four developmental curves were also constructed for the test results from the AVI test. Figure 9 displays the growth curve by age grade. As can be seen from this figure, a much different result was

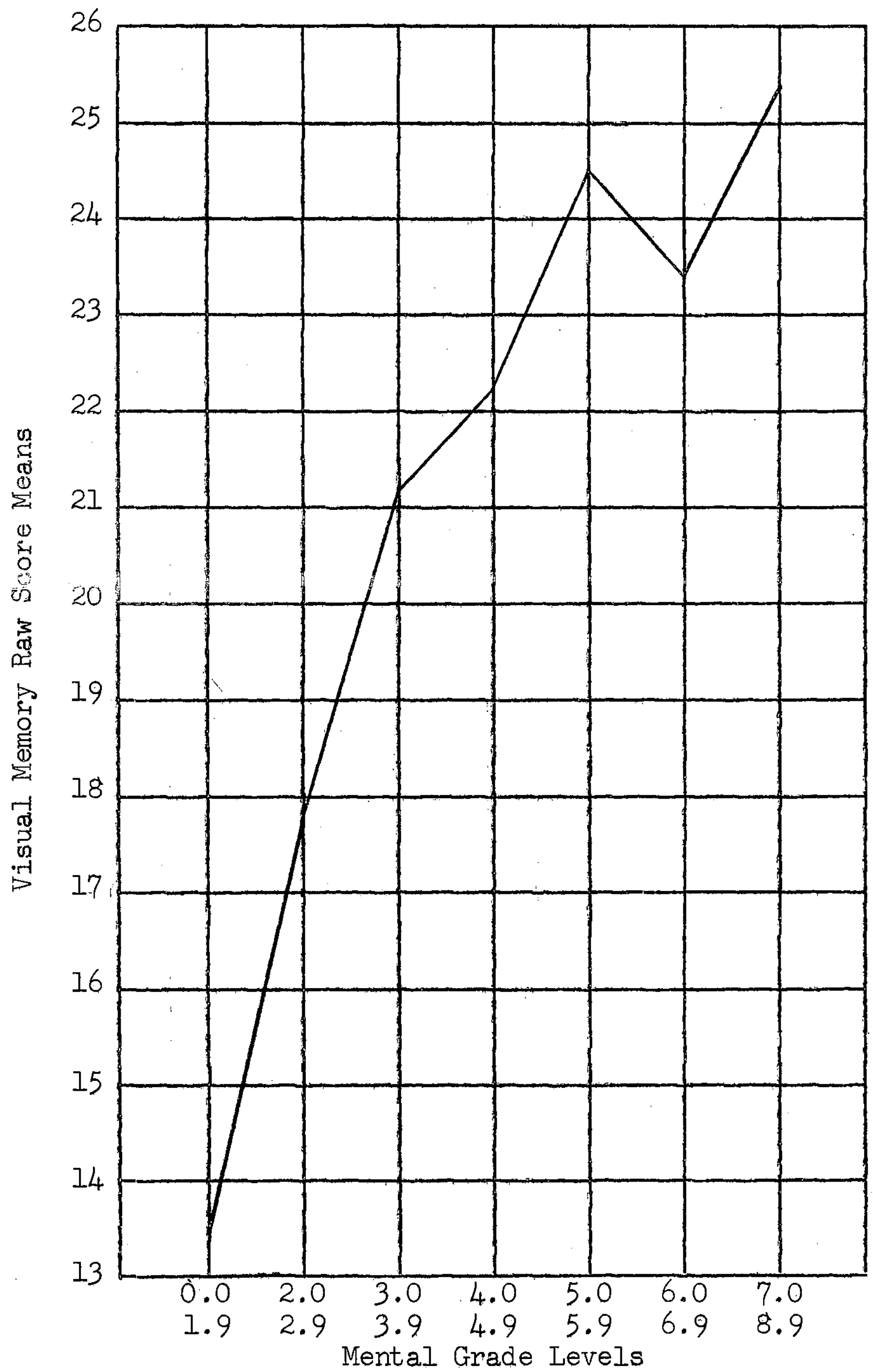

Figure 6. Developmental Growth Pattern for Visual Memory by Mental Grade

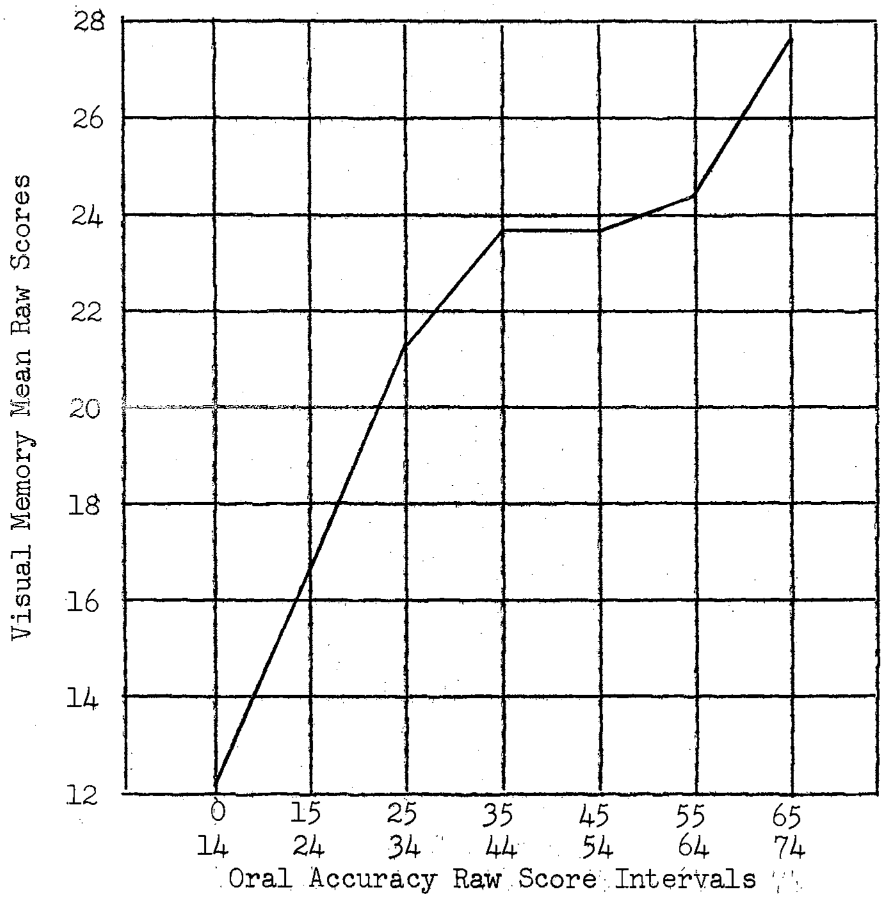

Figure 7. Developmental Growth Pattern for Visual Memory by Oral Accuracy

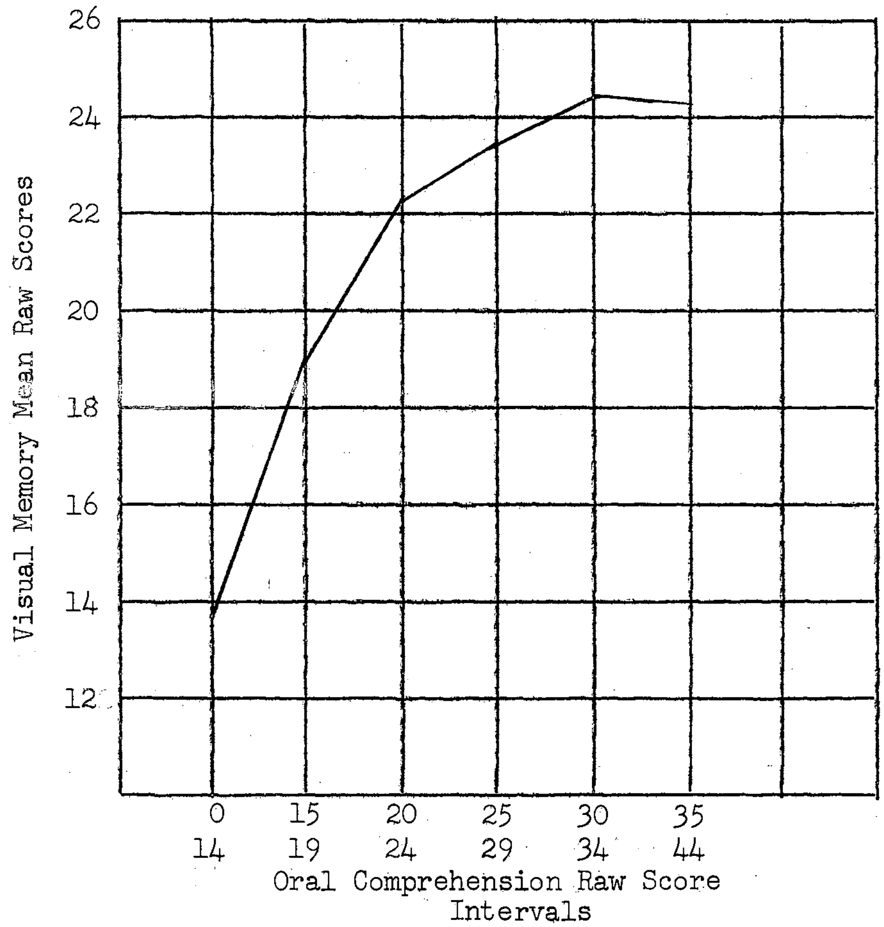

Figure 8. Developmental Growth Pattern for Visual Memory by Oral Comprehension

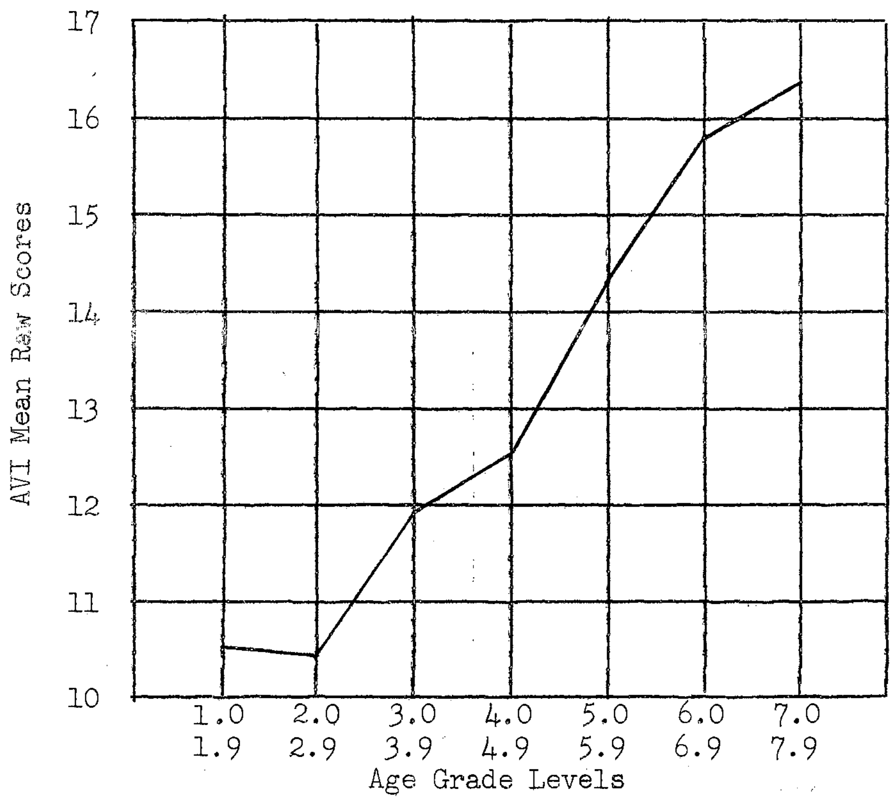

Figure 9. Developmental Growth Pattern for AVI by Age Grade

obtained in this study, than was found by Birch and Belmont (1965). They found that growth was most rapid in the first few years, slowed noticeably after this, and tended to reach a plateau at about fifth grade level.

However, the age grade curve for AVI shows an exactly opposite effect with the test used in this study. The erratic performance of the children in the first few intervals is difficult to explain, except in terms of sampling errors or the nature of the test, which might have been too difficult for children in the first few grades. However, there is no apparent tendency for the children's performance at later grade levels to diminish on this test of AVI. Quite evidently, the nature of the test is as important in growth curves, as is the ability that is supposedly being tapped.

In Figure 10, the curve for AVI by mental grade shows a fairly consistent growth throughout the intervals. There is no evidence of more rapid growth in the initial segment of the curve or of a plateauing effect. A straight line is the best description of this curve.

Figures 11 and 12 show the mean growth curves by oral accuracy and oral comprehension. As can be noted in Figure 11, this growth in AVI is quite rapid and consistent throughout the first five intervals, but a plateauing of AVI is observed in the last two intervals.

One logical conclusion that might be drawn from the plateau effect in Figure 11 is that AVI is an important ability throughout the first few years of reading growth but becomes less important after this time, since further gains in this ability were not noted. However, other conclusions may be equally valid. For example, one other logical interpretation could be that this ability is closely tied to

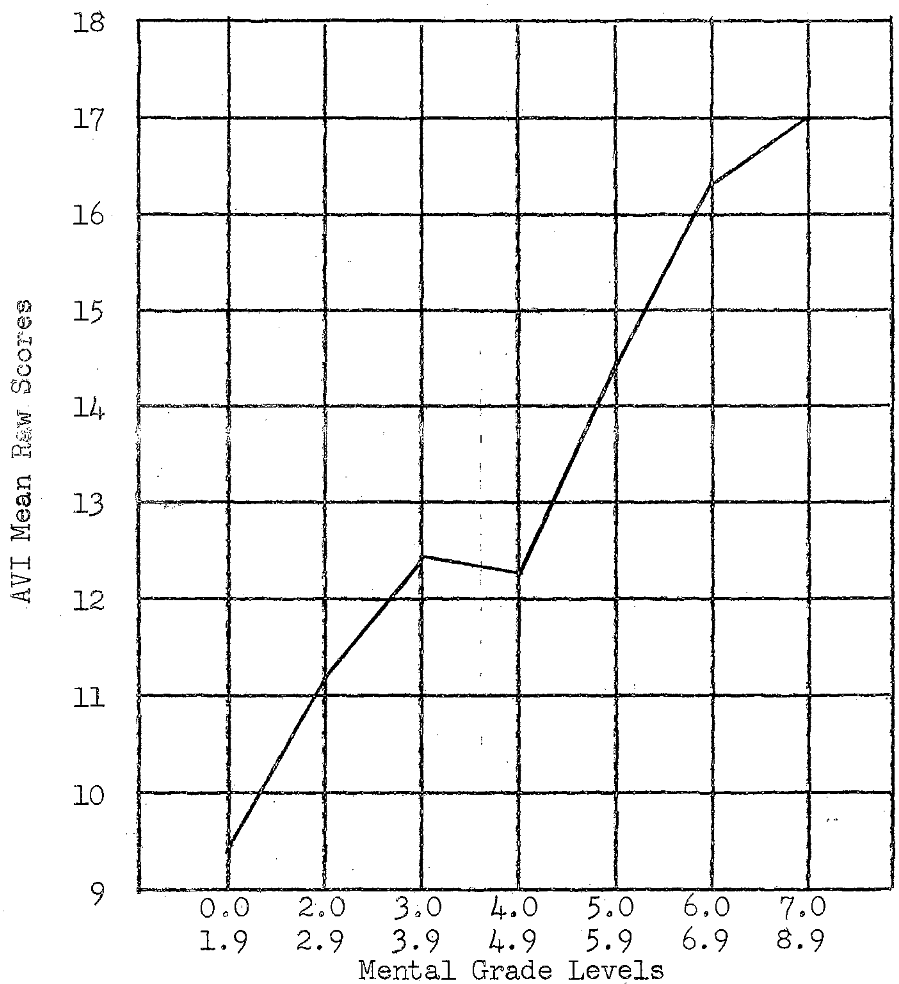

Figure 10. Developmental Growth Pattern for AVI by Mental Grade

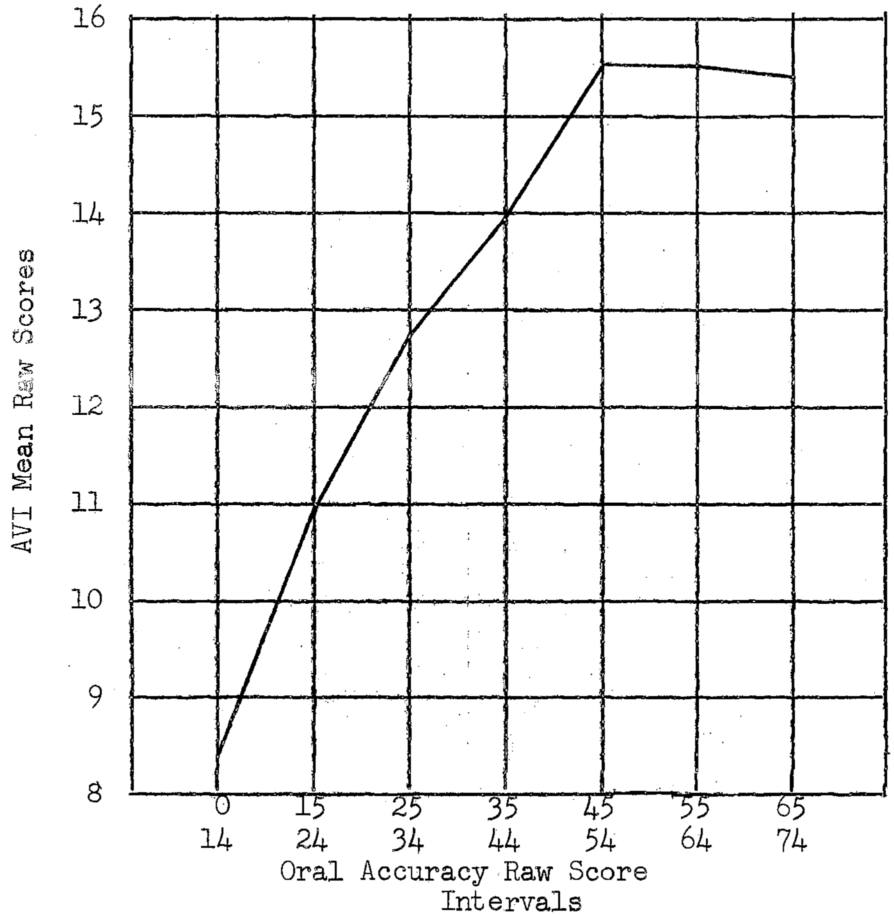

Figure 11. Developmental Growth Pattern for AVI by Oral Accuracy

chronological or mental age growth. If many youngsters in the last two intervals were reading above their age levels, they would not have a growth curve that showed continued growth by oral accuracy.

To add to the difficulty of interpreting the results of the AVI test used with this sample, Figure 12 shows the developmental curve based on oral comprehension. As can be observed, AVI, considered developmentally by oral comprehension, has a rather smooth and even growth throughout all intervals, with no observable tendency to plateau.

Growth in AVI by oral comprehension appears most rapid between the first and second intervals, but there is no indication that the line of best fit for this curve is not a straight line. Low scores in the first interval may be due to the nature of the test difficulty rather than to a rapid increase in AVI performance.

In testing the third and fourth hypothesis for AVI ability, the first of these hypotheses can be rejected with some confidence only on the curve by oral accuracy. This curve displayed a definite plateau indicating a cessation in AVI growth. The second hypothesis, that there is no indication that growth in ability is most rapid in the initial segment of the curve, cannot be rejected for any of the four curves of AVI with any high degree of confidence.

The developmental growth of AVI, as indicated from these curves, appears to be rather even and consistent. The one exception noted was in the curve of AVI by oral accuracy, where a tendency toward a plateauing of ability was indicated.

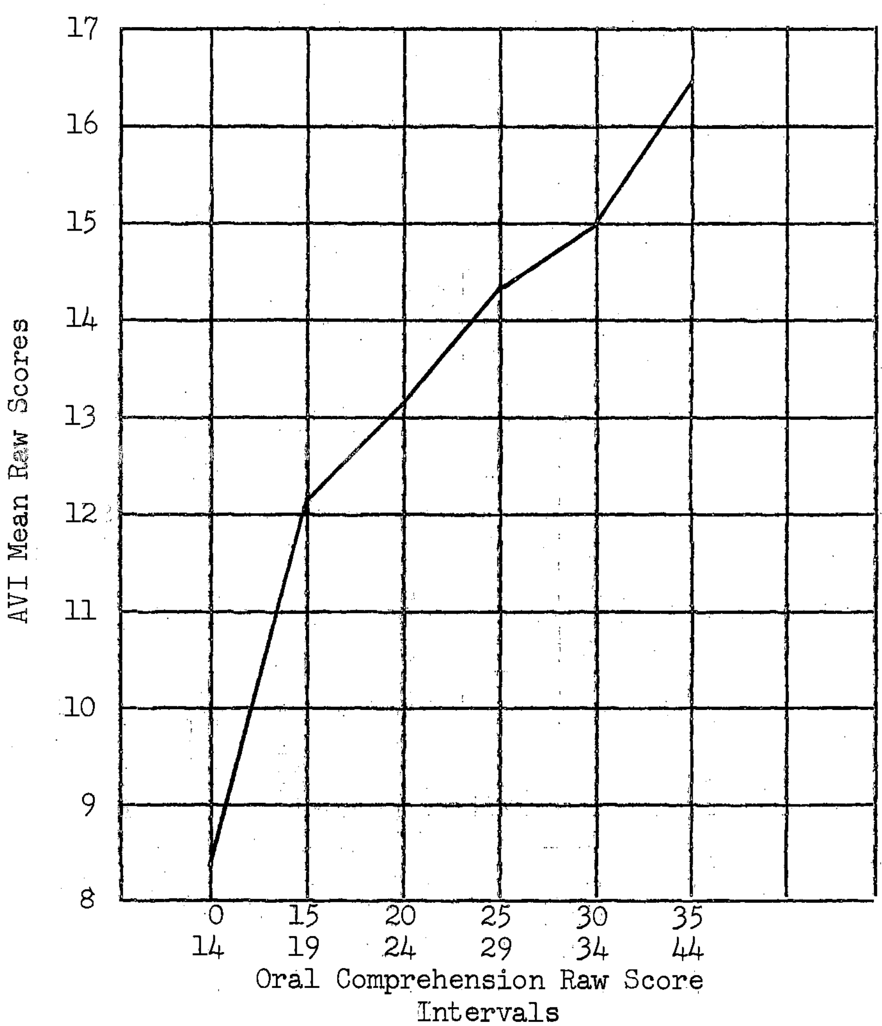

Figure 12. Developmental Growth Pattern for AVI by Oral Comprehension

Visual-Auditory Integration

As can be observed in Figure 13, the growth curve for VAI by age grade is rather consistent and regular and shows a straight line relationship between these factors. It should be noted that growth between the first two intervals is similar to the growth at this point on the test of AVI by age grade, Figure 9.

Figure 14 shows the growth curve for VAI by mental grade. As can be noted from this graph, growth is quite rapid throughout the mental grade ranges. Only one non-significant fluctuation appears in this curve, which otherwise exhibits a rather definite straight line relationship.

The growth curve for VAI by oral accuracy is quite regular up to the last interval. While this ability may be approaching a plateau level at this last interval, there is not enough evidence from this one interval to support this conclusion from this data. Again, a straight line relationship is indicated from this graph in Figure 15.

Figure 16, which displays the VAI curve determined by oral comprehension, shows a definite straight line relationship exists between these two factors. All variations within this curve are minor.

Thus, all four curves constructed to demonstrate the growth in VAI ability in this sample exhibit linear relationships when graphed by age grade, mental grade, oral accuracy, or oral comprehension. Because these relationships do indicate straight line relationships exist, both hypotheses three and four must be retained for VAI. These hypotheses were that no plateau level existed which indicated a cessation in ability growth and that growth was not more rapid in the initial segment of the curve.

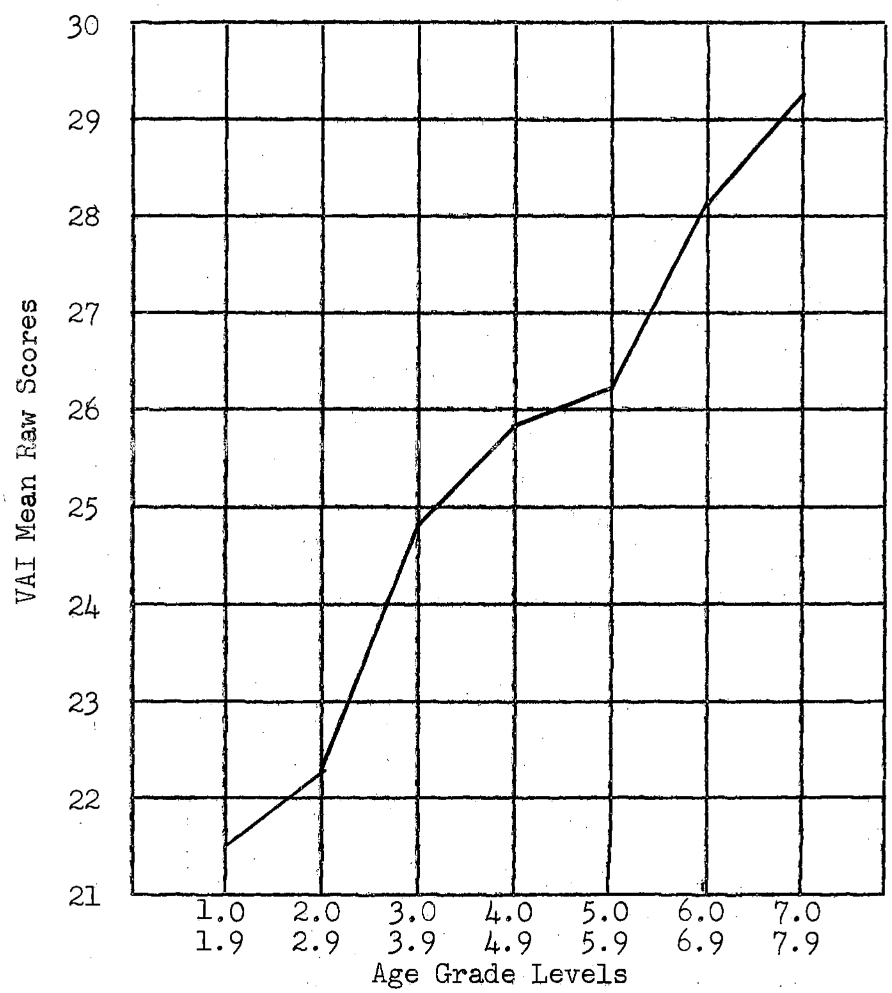

Figure 13. Developmental Growth Pattern for VAI by Age Grade

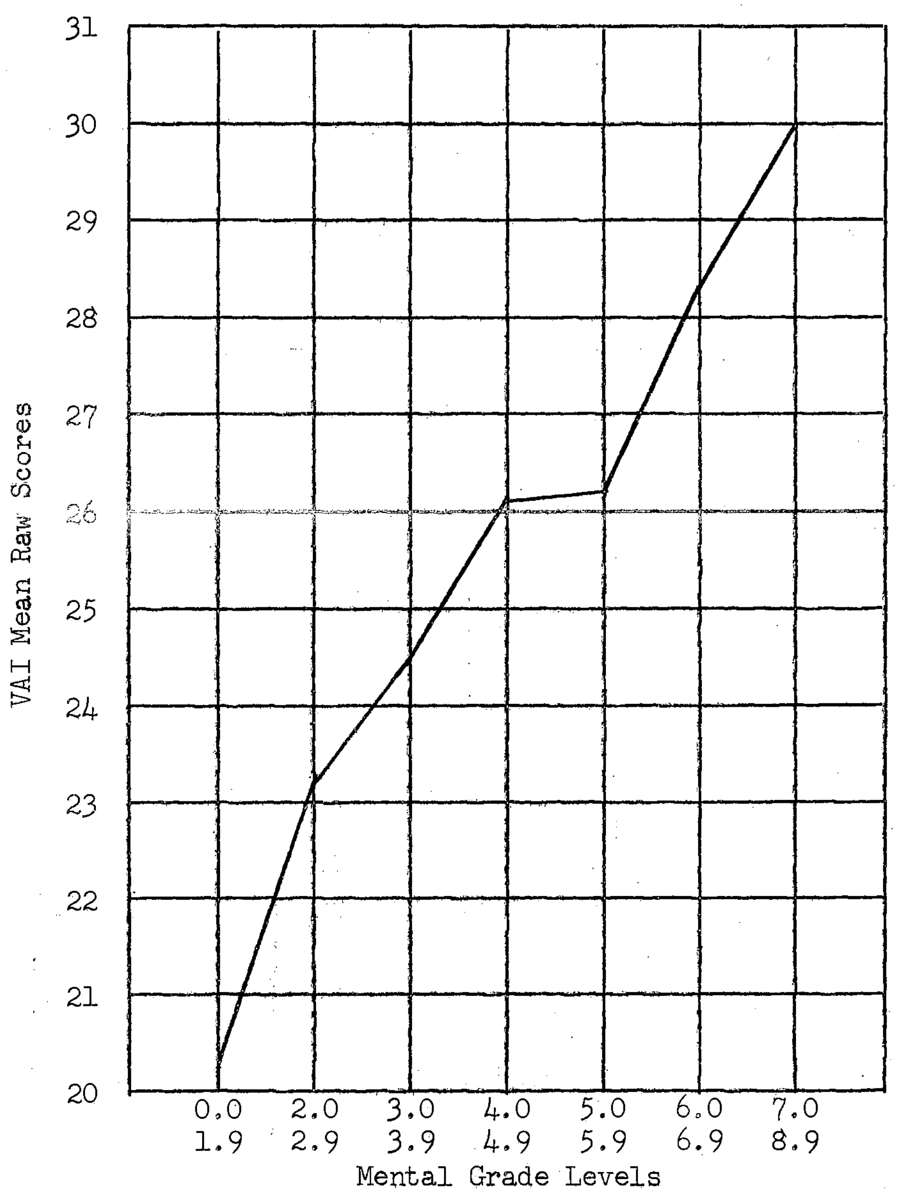

Figure 14. Developmental Growth Pattern for VAI by Mental Grade

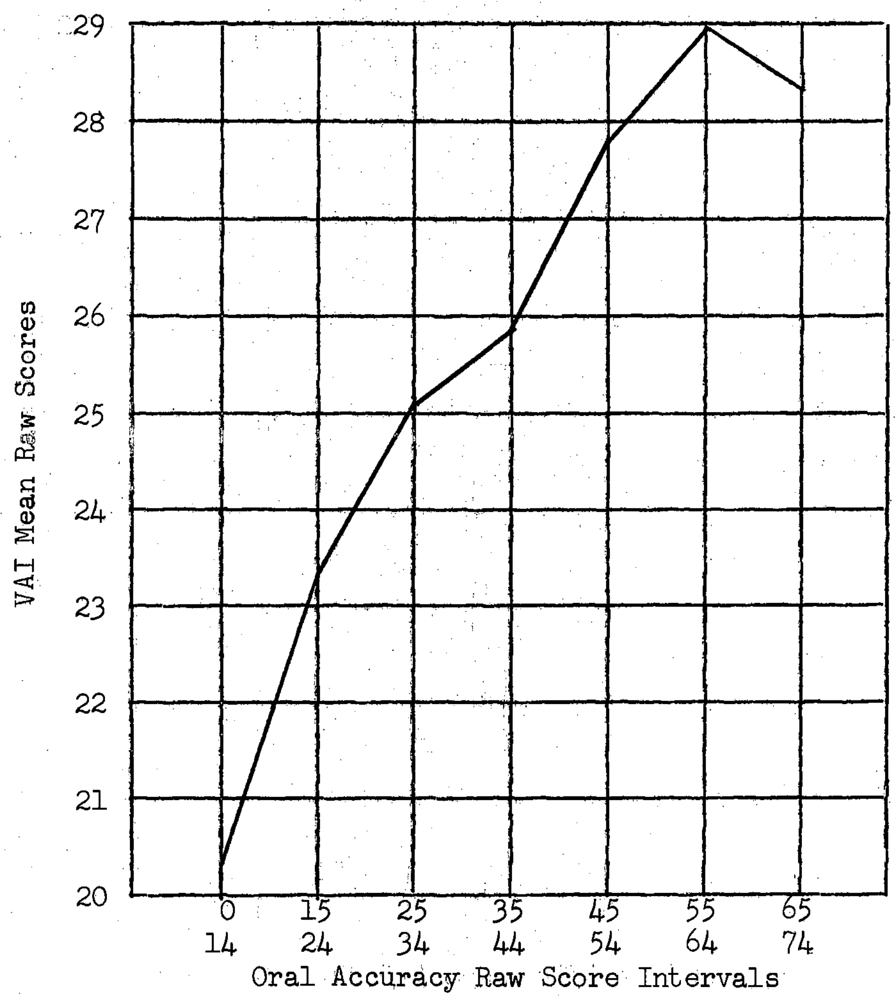

Figure 15. Developmental Growth Pattern for VAI by Oral Accuracy

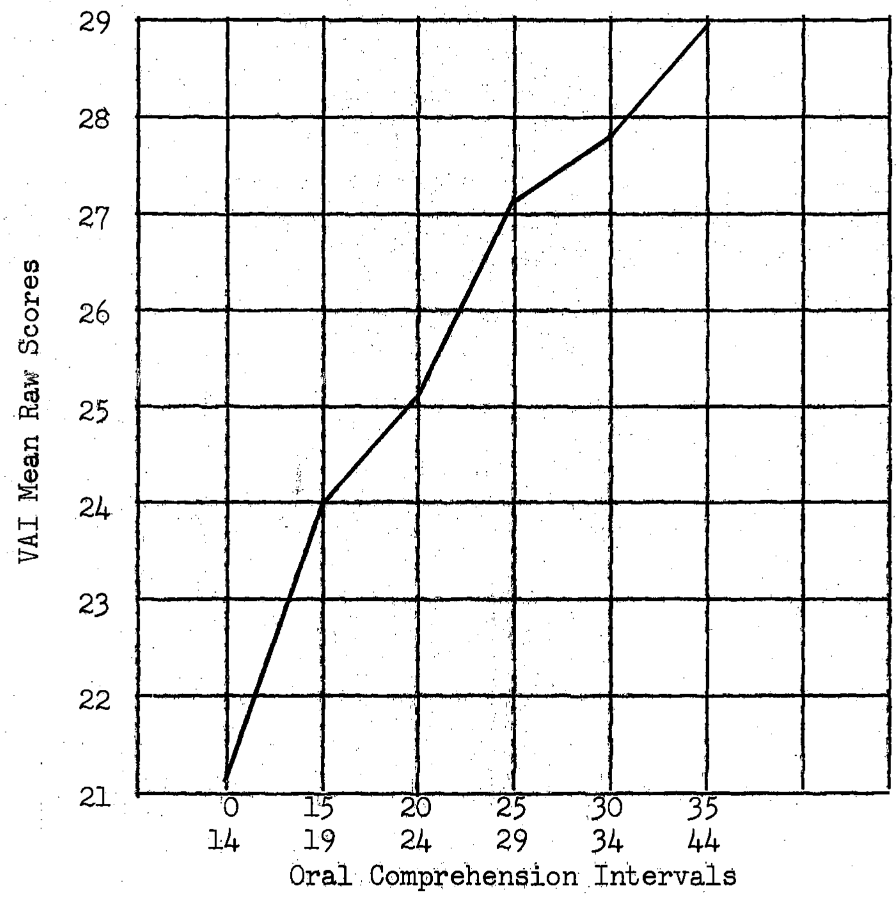

Figure 16. Developmental Growth Pattern for VAI by Oral Comprehension

Two hypotheses were tested in this section of Chapter IV by the construction of sixteen graphs which displayed the developmental growth patterns of four constructs: auditory memory, visual memory, AVI, and VAI, as tested in this study. The two hypotheses tested were that no plateaus in the developmental curves would be apparent and that growth in ability would not be most rapid in the initial segment of the curve.

The results of testing these two hypotheses are that:

1. These two null hypotheses cannot be rejected for either the test of auditory memory or the test of VAI. Both of these constructs, as measured, exhibited straight line relationships when graphed by age grade, mental grade, oral accuracy, or oral comprehension.

2. The test of AVI showed growth that was linear in nature, except for a plateau level for this ability by oral accuracy. Thus, both hypotheses must be retained for AVI, with the one exception that was noted.

3. The test of visual memory displayed growth that was most rapid during the initial segment of the curve and that reached a plateau level during the final segment. Both hypotheses three and four can be rejected for the test of visual memory used in this study.

Now that the nature of the growth of these constructs has been examined, the next section of this chapter will explore the possibility that there are significant differences between the performances of boys and girls on the four constructed tests.

Analysis of Variance for the Constructed Tests

Another aspect of the developmental growth of abilities, as tested by the four constructed tests in this study, is to determine whether there were significant differences between the performances of boys and girls at the different grade levels on any of these tests. An analysis of variance was performed on the data to test the fifth hypothesis, which was stated:

There is no significant difference between the mean scores on the four constructed tests of boys and girls at each grade level in this study.

Table IV reports the results of the analyses of variance performed to test this hypothesis. As can be seen from this table, only two critical F ratios were significant and indicate a significant difference between the performances of boys and girls at a grade level on one of the tests.

The performance of the second grade girls was significantly higher than the performance of the second grade boys on the test of VAI at the .05 level, and the sixth grade girls performed significantly higher than the sixth grade boys on the test of AVI at the .05 level.

In interpreting these two significant differences, it should be remembered that the sixth grade girls had IQ scores that were significantly higher than the sixth grade boys at the .05 level and the second grade girls had oral accuracy scores significantly higher than the second grade boys at the .05 level. These two sampling fluctuations could account for the differences in AVI and VAI performances.

TABLE IV

SUMMARY OF THE ANALYSES OF VARIANCE BETWEEN SEXES ON AUDITORY MEMORY, VISUAL MEMORY, AVI, AND VAI

	Critical F Ratios Between Sexes			
Grades	Auditory Memory	Visual Memory	AVI	VAI
First.....	0.07	0.47	0.00	0.12
Second....	3.32	1.40	1.31	6.74*
Third.....	1.44	2.77	0.13	2.59
Fourth....	0.20	2.27	0.51	0.39
Fifth.....	0.26	0.06	0.45	0.07
Sixth.....	0.25	0.62	7.17*	3.26

*F ratio is significant at the .05 level with values greater than 4.20.

In general, it can be observed that there were quite small differences between the performances of the two sexes with little indication of sex based superiority.

Correlations Between Variables in the Study

Another important way to examine constructed tests is to examine the correlation matrix created by calculating correlations between all of the variables. Table V presents such a matrix for the tests and other variables in this study. It was used to test the sixth hypothesis which stated:

There is no significant correlation between the tests of auditory-visual integration and visual-auditory integration; and there are no significant correlations between either of these two tests and auditory memory, visual memory, age grade, or mental grade.

As can be seen from Table V, all of the correlation coefficients generated from the tests and descriptive data are relatively high, ranging from .40 between AVI and auditory memory to .93 between age grade and mental grade. Since correlations as large as .195 are significant at the .05 level and ones as large as .254 are significant at the .01 level, all correlations in this matrix are statistically significant. On this basis, the null hypothesis above can be rejected.

Another interpretation of correlation coefficients is to determine what proportion of the variance between two variables is explained by the correlation. Squaring the coefficient of correlation (r^2) produces the coefficient of determination, or the proportion of the Y variance that is attributable to the relation of Y (the predicted variable) to X (the predictive variable). Also, the coefficient of nondetermination

TABLE V

MATRIX OF CORRELATION COEFFICIENTS

	1	2	3	4	5	6	7	8
1. Age Grade............	1.00	.93	.73	.75	.45	.55	.52	.54
2. Mental Grade.........		1.00	.74	.77	.47	.59	.58	.60
3. Oral Accuracy........			1.00	.89	.57	.67	.56	.56
4. Oral Comprehension...				1.00	.49	.62	.57	.57
5. Auditory Memory......					1.00	.51	.40	.49
6. Visual Memory........						1.00	.53	.47
7. AVI..................							1.00	.57
8. VAI..................								1.00

Correlations as large as .195 are significant at the .05 level.
Correlations as large as .254 are significant at the .01 level.

$(1 - r^2)$ is the proportion of variance that is not explained by the correlation between two variables.

Transforming the coefficient of correlation between AVI and VAI into a coefficient of determination yields a percentage value of 32.5. This means that 32.5 per cent of the variance in the prediction of scores for one integration test by use of the other integration test is being accounted for by the correlation. The proportion of variance not explained is 67.5 per cent, which indicates that the correlation between two measures of integration is not extremely large.

The coefficients of determination between AVI and the other variables in hypothesis six are rather low. These values are age grade (27.3), mental grade (33.5), auditory memory (16.3), and visual memory (27.8). The coefficients of determination for the variables associated with VAI are: age grade (29.5), mental grade (36.4), auditory memory (24.0) and visual memory (21.9).

All of these coefficients of determination are explaining only a small proportion of the variance associated with the prediction of the two integration tests. The variable that explains the smallest proportion of variance in the prediction of both integration measures is the memory test in the same modality.

Thus, while the coefficients of correlation from Table V are significantly different from zero at the .01 level, the majority of variance is unaccounted for by these correlations.

Factor Analysis

To determine the factor structure of the four constructed tests and the two reading measures, these six variables were entered into a computer program to determine the existing factor structure through a principal component solution with a varimax rotation. Table V has already presented the correlation matrix, and Table VI shows the data derived from the factor analysis. The hypothesis to be tested was number seven which was stated:

There is no factor which accounts for most of the variance in the factor analysis of results from the four constructed tests, oral accuracy and oral comprehension.

As can be seen from Table VI, the results from the factor analysis were that only one large common factor emerged, which made rotation of the matrix impossible. Thus, hypothesis seven must be rejected for this study.

The Significance of Multiple Correlations Between Predictive Variables and the Two Reading Criteria

Another way of examining constructs of reading, as they have been tested, is to determine the significance of including these variables with mental age in regression equations to predict some measures of general reading ability. Mental age is often used in multiple regression correlations in educational research because of the great influence of mental age in many developmentally distributed variables.

To eliminate the effect of mental age in examining the predictive efficiency of the four constructed tests, each of these four tests were added separately with mental grade in multiple regression equations to predict both oral accuracy and oral comprehension.

TABLE VI

DATA DERIVED FROM FACTOR ANALYSIS

	Factor Loadings	Vectors
Oral Accuracy.......	.90	0.458
Oral Comprehension..	.88	0.447
VAI................	.76	0.385
AVI................	.75	0.384
Auditory Memory.....	.71	0.362
Visual Memory.......	.80	0.405

Eigenvalues 3.845
Cummulative Percentage of Eigenvalues 0.641
Only one factor was retained, and no rotation was possible

The computer program used for multiple regression did not print out partial correlations, but the significance of both predictive variables to each equation was tested. This was done by dividing the regression coefficient for each variable in the regression by its appropriate standard error. This tests the significance from zero of the predicted slope line value in the regression equation.

Table VII contains the data from the multiple regression equations computed to predict oral accuracy and oral comprehension by adding each of the constructed tests to mental grade. This data was used to test the eighth hypothesis which was stated:

There are no significant contributions in predicting the reading criteria made by adding any of the four constructed tests to mental grade in multiple regression equations.

As can be seen from Table VII, all of the t values computed for mental grade are large and significant at the .001 level. While the computed t values for the constructed tests are smaller than the t values for mental grade, they are also significant values. Thus, hypothesis eight can be rejected at either the .01 or .001 levels for all the tests: AM, VM, AVI and VAI.

Since the single correlation from Table V between mental grade and oral accuracy was .74 and between mental grade and oral comprehension was .77, the multiple correlations reported in Table VII have not greatly increased the predictive efficiency of mental grade alone, as measured by coefficients of determination.

The variable which added the most in predicting both reading criteria was visual memory. The gain in the coefficient of determination in predicting oral accuracy was from 55.2 per cent with mental

TABLE VII

MULTIPLE LINEAR REGRESSION OF THE CONSTRUCTED TESTS AND MENTAL GRADE UPON ORAL READING SCORES

Equation Number	Intercept	Independent Variables	Dependent Variables	Regression Coefficients	t	Multiple Correlations
1	-15.01	MG	OA	0.52	11.53**	.78
		AM		5.88	5.28**	
2	-6.92	MG	OA	0.45	9.38**	.80
		VM		1.07	6.42**	
3	1.42	MG	OA	0.53	10.53**	.76
		AVI		0.80	3.16*	
4	-4.51	MG	OA	0.05	10.35**	.75
		VAI		0.64	2.74*	
5	2.27	MG	OC	0.29	12.92**	.78
		AM		1.74	3.08*	
6	3.81	MG	OC	0.26	10.81**	.79
		VM		0.38	4.46**	
7	5.65	MG	OC	0.28	11.36**	.78
		AVI		0.42	3.46**	
8	2.82	MG	OC	0.28	11.20**	.78
		VAI		0.32	2.85*	

* = t value significant at the .01 level
** = t value significant at the .001 level

grade alone to 63.7 per cent with visual memory added; the increase in predicting oral comprehension was from 58.7 per cent for mental grade alone to 62.9 per cent with visual memory added. Thus, while all constructed tests added significantly to prediction with mental grade, the multiple correlations for these variables with mental grade contributed less than 9 per cent to the prediction of oral accuracy and less than 5 per cent to the prediction of oral comprehension, as measured by computing coefficients of determination.

The Combination of Variables into Multiple Regression Equations to Predict the Reading Criteria

In order to determine the effectiveness of the four predictive tests constructed for use in this study, these four tests were entered, one at a time, in multiple regression equations. The order of entering these tests was visual memory, auditory memory, VAI, and AVI. After the four constructed tests had been entered into equations, mental grade was entered, also. This permitted checking on the significance of the four constructed tests after accounting for mental age factors.

The correlation matrix for this problem is essentially the same as the one reported in Table V so it has not been repeated. Table VIII gives the computed t values for all of the combinations of the predictive variables that were made in estimating oral accuracy. These t values were computed by dividing the individual regression coefficients by their standard errors. This technique tests the significance of adding each variable to the equation.

TABLE VIII

MULTIPLE LINEAR REGRESSION IN SINGLE STEP PROGRESSION OF THE CONSTRUCTED TESTS AND MENTAL GRADE UPON THE ORAL ACCURACY SCORES

Equation Number	Intercept	Independent Variables	Dependent Variables	Regression Coefficients	t	p	Multiple Correlations
1	-7.06	VM	OA	2.00	12.2	.001	.67
2	-27.17	VM	OA	1.54	8.6	.001	.72
		AM		6.31	5.0	.001	
3	-37.41	VM	OA	1.34	7.4	.001	.75
		AM		4.62	3.6	.001	
		VAI		0.89	4.0	.001	
4	-36.24	VM	OA	1.19	6.3	.001	.76
		AM		4.47	3.5	.001	
		VAI		0.65	2.7	.01	
		AVI		0.68	2.5	.05	
5	-22.97	VM	OA	0.81	4.6	.001	.82
		AM		3.70	3.2	.01	
		VAI		0.16	0.7	NS	
		AVI		0.28	1.1	NS	
		MG		0.37	6.9	.001	

As can be seen from Table VIII, mental grade has the highest computed t value in the multiple regression equation with the four constructed tests predicting oral accuracy. Both visual memory and auditory memory are significant predictors in this same equation. These significant contributions to the multiple regression equation can be used to reject the null hypothesis which was stated:

There are no significant contributions in estimating the reading scores made by any of the four constructed tests when all four tests are added with mental grade in multiple regression equations.

This hypothesis can be rejected for both visual and auditory memory, while it must be retained for the two tests of integration ability. As can be seen from Table VIII, the computed t values for AVI and VAI are quite small and non-significant in the final equation.

Table IX gives the data from the regression equations upon oral comprehension. As can be seen from the fifth equation in this table, mental grade has the highest computed t value in the multiple regression equation with the four constructed tests. This value of 7.9 is significant at the .001 level. Visual memory is the only other significant contributor to the multiple regression with a t value of 3.0 which is significant at the .01 level.

The ninth hypothesis can be rejected for visual memory, but it must be retained for auditory memory, AVI, and VAI. This hypothesis was that none of the constructed tests could significantly contribute to multiple regression equations with all four tests and mental grade in estimating oral comprehension.

TABLE IX

MULTIPLE LINEAR REGRESSION IN SINGLE STEP PROGRESSION OF THE CONSTRUCTED TESTS AND MENTAL GRADE UPON THE ORAL COMPREHENSION SCORES

Equation Number	Intercept	Independent Variables	Dependent Variables	Regression Coefficients	t	p	Multiple Correlations
1	3.72	VM	OC	0.93	10.5	.001	.62
2	-4.11	VM	OC	0.75	7.5	.001	.65
		AM		2.46	3.5	.001	
3	-11.07	VM	OC	0.61	6.2	.001	.70
		AM		1.31	1.9	NS	
		VAI		0.60	5.0	.001	
4	-10.27	VM	OC	0.50	5.0	.001	.72
		AM		1.20	1.8	NS	
		VAI		0.44	3.4	.001	
		AVI		0.47	3.2	.01	
5	-2.34	VM	OC	0.28	3.0	.01	.81
		AM		0.75	1.3	NS	
		VAI		0.15	1.2	NS	
		AVI		0.23	1.8	NS	
		MG		0.22	7.9	.01	

Summary

This chapter has presented the statistical results from the treatment of the data. Analysis of variance was used to test the possibility that the sample sub-groups might contain significant differences among the grade levels on IQ scores. Analysis of variance also was used to explore differences between the sexes on IQ or oral accuracy which might bias some of the findings of this investigation.

Sixteen graphs were constructed showing the developmental characteristics of four constructs of reading sub-abilities: auditory memory, visual memory, auditory-visual integration, and visual-auditory integration. Each of these four abilities was graphed by age grade, mental grade, oral accuracy, and oral comprehension. Analysis of variance was used to determine whether there were sex-based differences between the performances of boys and girls on the four constructed tests.

The correlation matrix for the variables in this study was examined to explore the interrelatedness of the factors. The significance of the correlations was examined by testing their difference from zero and by computing coefficients of determination to explore the proportion of variance in prediction that was explained by the relationships. A factor analysis explored the factor structure of the four constructed tests, oral accuracy, and oral comprehension.

Multiple regression analysis was used to test the predictive effectiveness of the four constructed tests. This analysis regressed all four constructed tests with mental grade in single equations to predict the reading criteria, and it built step-wise regression equations, adding each constructed test and finally mental grade, to predict the reading criteria.

These analyses will be discussed in more detail in Chapter V, and the conclusion and recommendations from this study will also be presented.

CHAPTER V

SUMMARY AND CONCLUSIONS

General Summary of the Investigation

This study explored four constructs, or sub-abilities, of reading: auditory memory, visual memory, auditory-visual integration, and visual-auditory integration. Four test instruments were created to measure these factors, and coefficients of reliability were computed for these tests from the results of this study.

The sample for the study was 180 randomly selected children from the elementary school population of a small town in north central Oklahoma. This sample was stratified to include fifteen boys and fifteen girls at each of the six grade levels who had scored within one standard deviation from the mean on total IQ on a screening instrument. The instrument used was the California Test of Mental Maturity (1963), which had been routinely given to all elementary children in January of 1969 by the school counselor.

The testing of the sample in this study was completed during March and April of 1969. All 180 children were individually administered the Gilmore Oral Reading Test, a test of auditory memory, and a test of visual memory. Following the individual testing, the children were administered group tests of auditory-visual integration and visual-auditory integration.

The statistical treatment of the data to test nine hypotheses included these analyses:

1. Coefficients of reliability were computed for the four constructed tests to determine the amount of confidence that could be placed in them to consistently measure the constructs in this manner.

2. Analysis of variance for one-way design was used to explore possible sampling errors and to examine sex-based differences in performance on the four constructed tests.

3. Sixteen graphs were constructed to explore the developmental growth characteristics of the four constructs examined: auditory memory, visual memory, auditory-visual integration, and visual-auditory integration. Growth curves were constructed for each of these factors in four ways: by the children's age grade, mental grade, oral accuracy performance, and oral comprehension performance. These sixteen growth curves were examined to determine whether growth in these abilities was most rapid in the initial segment of the curve and whether the growth reached a plateau level at some place in the curve.

4. The correlation matrix for the variables was examined to determine the interrelatedness of the constructs as tested. A factor analysis of the reading variables explored the factor structure underlying these variables as tested.

5. Multiple regression equations were constructed to determine the effectiveness of the four constructed tests in predicting oral accuracy and oral comprehension scores.

These statistical analyses permitted testing nine hypotheses. The results of the study will be discussed next in the conclusions.

Conclusions of the Study

The following conclusions can be drawn from the results of the statistical treatment of the data:

1. Three of the four constructed tests have coefficients of reliability higher than .90, and the fourth measure, auditory memory, has a reliability of .87. Thus, all four measures could be considered reliable measures for the purpose of this study. It should be noted that the reliability coefficients for these tests vary somewhat from grade to grade. Appendix D presents the coefficients of reliability for these four tests by grade levels.

As can be seen from examining these coefficients of reliability at the different grade levels, the test of auditory memory has a coefficient of .58 at first grade, while the total reliability for the test is .87 and the other five grade levels have coefficients above .80. In a similar manner, the reliability computed for first graders on the test of visual memory is .66. The total reliability for the test is .92 and no other grade has a reliability coefficient below .80. The coefficients at first grade on the two integration tests are not greatly different than the reliabilities reported for other grades.

The discrepancies between the reliability coefficients at first grade and the other grades may indicate that these tests of auditory and visual memory are not appropriate for the younger children, while still being reliable measures over the range of six grades.

2. Analysis of variance was used to treat the data from the study to determine if the selected sample contained any bias that might influence other results of the study. Two hypotheses were stated and tested to check on this possibility of sampling errors. These

hypotheses are stated that

> there are no significant differences among the mean IQ scores of the grade levels in this study; and there are no significant differences between the mean IQ or oral accuracy scores of the boys and girls at each grade level in this study.

The analysis of variance to test this first hypothesis produced a non-significant F ratio of 1.3 for the variance in IQ among the six grade levels. Most of the variance in IQ for the sample is evidently within the grade levels and not among these levels. Developmental data derived from this sample should not be biased by fluctuations in intelligence from grade to grade.

The second hypothesis above explored the variance within the grade levels to determine whether there were significant differences between the performances of the boys and girls at each level in the sample. The analysis of variance on IQ between sexes disclosed only one significant difference. The sixth grade girls had a mean IQ score significantly higher than the mean score of the boys at the .01 level of significance.

Two significant differences were revealed by the analysis of variance on mean oral accuracy performance. The second grade girls and the fourth grade boys had mean scores significantly higher than their opposite sex at the .05 level. The significant difference between the mean oral accuracy scores of girls and boys at second grade may reflect the normal differences in reading ability, favoring girls, that is often reported at this level. The difference favoring the boys at fourth grade level is more difficult to explain except in terms of sampling errors.

The results of the analysis of variance on mean IQ scores among the six grade levels indicate that there is no significant difference among these groups in the sample. Therefore, the developmental growth curves, considered in the next part of this section, should not be biased by extreme variations in mean IQ at the different grade levels.

The fourth part of this section deals with possible sex-based differences in performance on the four constructed tests. Since significant differences in performance were uncovered between the sexes on mean IQ or oral accuracy scores at second, fourth, and sixth grades, care will need to be used in further analyses of sex-based differences.

3. Four graphs were constructed for each of the abilities tested to display the growth patterns for auditory memory, visual memory, AVI, and VAI. Each of these factors were graphed by age grade, mental grade, oral accuracy, and oral comprehension. These graphs were then examined to test two hypotheses concerned with the developmental growth of these abilities. These two hypotheses are that

> there are no plateaus indicating a cessation of further growth in the developmental curves for the four constructed tests; and there are no indications from the developmental curves for the four constructed tests that growth in these abilities is most rapid in the initial segment.

All four curves displaying the growth in auditory memory ability could best be described as indicating straight line relationships to age grade, mental grade, oral accuracy, and oral comprehension. Neither of the hypotheses being tested could be rejected. There is no indication of a plateau of ability, and growth in auditory memory is not most rapid in the initial segment of the curves.

The four curves showing the developmental growth of visual memory indicate that this growth in ability is most rapid in the initial segment of the curves, and a plateau level in ability is being reached in the final part of the curves. Thus, both hypotheses are rejected for visual memory.

The examination of the four curves constructed for auditory-visual integration reveals a difference among them. Three of these curves, those graphed by age grade, mental grade, and oral comprehension, could best be described as indicating straight line relationships. The two null hypotheses cannot be rejected for these three curves, since growth is not most rapid in the initial curve segment and there is little indication of a plateauing in ability.

The curve constructed for AVI by oral accuracy intervals indicates that a plateauing of ability occurs in the final portion. There is no indication that growth is most rapid in the initial segment of the curve, since a straight line relationship exists up to the last two intervals. The first hypothesis could be rejected for this curve but not the second.

The constructed curves for visual-auditory integration can best be described as indicating straight line relationships exist between this variable and the four measures with which it was graphed. Thus, neither hypothesis can be rejected since the growth in ability does not indicate a plateau level is being reached and growth in ability is not most rapid in the initial curve segment.

4. The possibility that sex-based differences existed in the performances on the four constructed tests was checked by testing the

hypothesis that

> there are no significant differences between the mean scores on the four constructed tests of the boys and girls at each grade level in this study.

This hypothesis could be rejected for only two of the tests at one grade level. On the test of AVI, the performance of the sixth grade girls was significantly higher than the performance of the sixth grade boys at the .05 level, and the second grade girls have a mean score on the test of VAI that is significantly higher than the mean score of the second grade boys.

In considering these two significant differences, it should be remembered from part three that the sixth grade girls have mean IQ scores significantly higher than the sixth grade boys, and the second grade girls have mean oral accuracy scores higher than the second grade boys. Thus, these significant differences on the tests of AVI and VAI may result from differences in basic abilities between the boys and girls selected for the sample at these two grade levels. The main conclusion from testing the hypothesis is that there is little indication of a sex-based superiority on the four constructed tests.

5. Hypothesis six in this study is stated that

> there is no significant correlation between the tests of AVI and VAI; and there are no significant correlations between either of these tests and auditory memory, visual memory, age grade, or mental grade.

This hypothesis was tested by examining the correlation matrix between these variables. All of the correlations from this matrix in

Table V were statistically significant from zero at the .01 level, and hypothesis six was rejected for these correlation coefficients.

Examining these correlations by computing coefficients of determination (a technique of squaring the correlation coefficient, which gives the proportion of the variance associated in the prediction of one variable from another that is explained by the correlation) reveals that most of these correlations are not accounting for a majority of the variance in prediction. The coefficient of determination between auditory memory and auditory-visual integration is only 16.3 per cent, which indicates that 83.7 per cent of the variance between these variables is unexplained.

The coefficient of determination between visual memory and VAI is also quite small. Only 21.9 per cent of the variance is explained by this correlation. The coefficient of determination between the two integration tests, AVI and VAI, is only 32.5.

Thus, the hypothesis could be rejected because the correlations are statistically significant. However, there are indications that these correlations are lower than might be expected between such related tests. The variable that explains the smallest proportion of the variance in the prediction of the two integration tests is the memory test in the same modality, and the proportion of variance explained by the correlation between the two integration tests is not extremely large.

6. The factor analysis on the results of the four constructed tests, oral accuracy, and oral comprehension discloses one large factor that is common to all six measures. In view of the differences in

testing procedure and the apparent nature of the different tasks involved in these six measures, this finding is surprising.

No attempt will be made to identify this factor beyond suggesting several possibilities. This factor may well be a short-term memory ability that is apparently present in all of these measures, with oral accuracy being a possible exception. The ability to attend to a testing situation is involved in all six measures and this factor may be freedom from distractability. This factor may be one associated with general linguistic ability or even general mental ability as measured by intelligence tests. The possibilities are numerous and the exact identification is nearly impossible at present.

The important finding of this factor analysis is that all four constructed tests are measuring the same component factor that is closely tied to reading ability as measured by an oral reading test. This indicates that including all four instruments in a test battery to measure component processes of reading cannot be justified. This does not mean that the proposed constructs of reading, such as integration between the modalities, have been proven to be valueless components of the reading process. It may indicate, however, that tests using dot and dash patterns to measure integration abilities are questionable.

7. Multiple regression equations were constructed to examine the effectiveness of including auditory memory, visual memory, AVI, or VAI with mental grade in predicting oral accuracy or oral comprehension. Two sets of equations were constructed to test hypotheses eight and nine

> that there are no significant contributions in estimating the reading scores made by adding any of the four constructed tests to mental grade in multiple regression equations; and there are no

significant contributions in estimating the reading scores made by any of the four constructed tests when all four are added to mental grade in multiple regression equations.

The results of the set of equations used to test the eighth hypothesis are presented in Table VII (page 83).

The first set of equations reveals that all of the four constructed tests contribute significantly at the .01 or .001 levels with mental grade in estimating the oral accuracy or oral comprehension scores. The eighth hypothesis is rejected, since any of the four constructed tests adds significantly with mental grade in the prediction of the reading scores.

The multiple correlations from the regressions disclose that visual memory contributes the most to mental grade in estimating the reading criteria. The coefficient of determination for mental grade in estimating oral accuracy is 55.2 per cent, and it is increased to 63.7 per cent with visual memory added. The increase in predicting oral comprehension is from 58.7 per cent for mental grade alone to 62.9 per cent with visual memory added.

To test the ninth hypothesis, two sets of multiple regression equations were constructed. One set of equations estimates oral accuracy scores and one set estimates oral comprehension scores. In each of these sets of equations, the four constructed tests and mental grade are entered in a single step-type progression of variables. In these equations, all previously entered variables are automatically retained as each new variable is entered. The order of entry for the variables is visual memory, auditory memory, VAI, AVI, and mental grade.

For each of the five equations generated by adding variables, a multiple correlation is obtained, and the significance from zero of the regression coefficient for each variable in the equation is tested (Edwards, 1967, pages 252-253). Table VIII (page 85) presents the data derived from the regression equations predicting oral accuracy, and Table IX (page 87) presents the data from the prediction of oral comprehension scores.

In the prediction of oral accuracy, visual memory and auditory memory are the only tests that contribute significantly with mental grade when all five variables are entered in the regression. Visual memory is significant at the .001 level and auditory memory at the .01 level. In predicting oral comprehension with all five variables entered into the equations, visual memory is the only significant contributor with mental grade. It is significant at the .01 level.

The ninth hypothesis, that none of the constructed tests contribute significantly to prediction of the reading measures when all four tests are entered into multiple regression, could be rejected for both visual and auditory memory in the prediction of oral accuracy. Only the hypothesis for visual memory could be rejected in the prediction of oral comprehension.

In reviewing the data from all of the multiple regression equations, these conclusions can be drawn:

When any of the four constructed tests is added to mental grade, a significant increase in prediction of reading scores is made. The constructed test that adds the most to this prediction is visual memory. Mental grade and visual memory produce a multiple correlation of .80 to oral accuracy and .79 to oral comprehension.

In the prediction of oral accuracy, the four constructed tests all contribute significantly to prediction, and a multiple correlation of .76 is produced. Both visual memory and auditory memory are significant at the .001 level, VAI is significant at the .01 level, and AVI is significant at the .05 level in this equation.

When these four tests are used together to predict oral comprehension, visual memory and VAI are significant at the .001 level, AVI is significant at the .01 level, and auditory memory is non-significant.

If mental grade is added with the four constructed tests to predict oral accuracy, a multiple correlation of .82 is produced. This correlation is only slightly higher than the multiple correlation of .80 that is produced by visual memory with mental grade in estimating oral accuracy. In the equation containing all four constructed tests with mental grade, both AVI and VAI are non-significant predictors in estimating oral accuracy.

When mental grade is added with the four constructed tests to predict oral comprehension, a multiple correlation of .81 is produced. This correlation is only slightly higher than the .79 multiple correlation produced by visual memory and mental grade in predicting oral comprehension.

In summarizing the conclusions from this study, several findings appear more important than others. These points are:

1. The developmental growth curves constructed for auditory memory and visual-auditory integration indicate that a straight line relationship exists between each of these factors and age grade, mental grade, oral accuracy, and oral comprehension. This same type of relationship

appears for the test of auditory-visual integration, except in the curve plotted by oral accuracy. This curve indicates a plateauing of ability occurs in the better readers.

2. The growth curves for visual memory indicate that this ability has a very rapid growth in the initial segment of the curves, and a plateauing of ability occurs during the final curve segments.

3. There are no strong indications that any sex-based superiority in performance exists on the tests of auditory memory, visual memory, AVI, and VAI.

4. In examining interrelationships between the four constructed tests, the lowest correlations are between the integration tests and the memory test in the same modality. Only 32.5 per cent of the variance in predicting one integration test from the other is explained by the .57 correlation between AVI and VAI.

5. The factor structure of the four constructed tests, oral accuracy, and oral comprehension indicates that one large factor is accounting for the variance in these measures. This factor is not positively identified but several possibilities are noted.

6. All four constructed tests contribute significantly to predicting reading scores when entered individually with mental grade.

7. The four constructed tests in multiple regression predict oral accuracy with a multiple correlation of .76. All tests contribute significantly to the prediction.

8. The multiple correlation between the four constructed tests and oral comprehension is .72. Auditory memory does not contribute significantly to this equation with visual memory, AVI, and VAI.

9. When mental grade is added with the four constructed tests in estimating oral accuracy, a multiple correlation of .82 is produced. Neither AVI nor VAI contribute significantly to this equation.

10. In the equation to predict oral comprehension, mental grade and the four constructed tests produce a multiple correlation of .81. Of the four constructed tests, only visual memory is a significant predictor in this equation.

Recommendations

The findings of this study are basically negative ones. The two tests of integration ability are related to oral reading ability, but there is little indication that underlying component processes of reading are being measured by these tests. Both AVI and VAI are apparently measuring the same ability, as are auditory and visual memory, and this factor is highly related to oral reading. Because of this related factor structure, poor readers can be expected to do poorly on all four constructed tests, but this appears to be more of a casual relationship than a causal one.

The findings in this study are tied to an oral reading test. It is not certain that these results would be the same had a silent reading test been used. The findings of this study should be confirmed using a silent reading measure.

The use of any one of the four constructed tests with mental grade increases the precision of predicting the reading scores considerably. The test of visual memory increases this prediction the most, and this tool, or a modification of it, may prove to be of significant value to clinicians working with disabled readers. This test should be used with groups of disabled and normal readers to determine whether it can be used to distinguish between these children.

Using both the test of visual memory and the test of AVI with disabled readers would help prove or disprove the findings of Birch and Belmont (1964) with disabled readers. If integration type abilities are being measured in this kind of test, and this ability is an important function in reading, a test of AVI should discriminate disabled from normal readers at least as well as the visual memory test.

While the findings of this study are largely negative in nature, it is hoped that research into the component abilities and processes involved in reading will be stimulated by this study. This researcher does believe that component abilities in reading exist and that they can be measured.

SELECTED BIBLIOGRAPHY

Alwitt, Linda F. "Decay of Immediate Memory for Visually Presented Digits Among Nonreaders and Readers." Journal of Educational Psychology, LIV (1963), 144-148.

Anderson, Virgil A. "Auditory Memory Span As Tested by Speech Sounds." American Journal of Psychology, LII (1939), 95-99.

Beery, Judith W. "Matching of Auditory and Visual Stimuli by Average and Retarded Readers." Child Development, XXXVIII (1967), 827-833.

Birch, Herbert G. and Lillian Belmont. "Auditory-Visual Integration in Normal and Retarded Readers." American Journal of Orthopsychiatry, XXXIV (1964), 852-861.

Birch, Herbert G. and Lillian Belmont. "Auditory-Visual Integration and Reading Ability in School Children." Perceptual and Motor Skills, XX (1965), 295-305.

Blankenship, Albert B. "Memory Span: A Review of the Literature." Psychological Bulletin, XXXV (1938), 1-25.

Bond, Guy L. The Auditory and Speech Characteristics of Poor Readers. New York: Teachers College, Columbia University Contributions to Education, 657 (1935).

Brenner, Roy. "An Experimental Investigation of Memory Span." Journal of Experimental Psychology, XXVI (1940), 467-482.

Edwards, Allen L. Statistical Methods, 2nd ed. New York: Holt, Rhinehart, and Winston, Inc., 1967.

Ewers, Dorothea W. F. "Relations Between Auditory Abilities and Reading Abilities: A Problem in Psychometrics." Journal of Experimental Education, XVIII (1950), 239-262.

Ford, Marguerite P. "Auditory-Visual and Tactual-Visual Integration in Relation to Reading Ability." Perceptual and Motor Skills, XXIV (1967), 831-841.

Gibson, Eleanor J., James J. Gibson, Anne D. Pick, and Harry Osser. "A Developmental Study of the Discrimination of Letter-Like Forms." Journal of Comparative and Physiological Psychology, LV No. 6 (1962), 897-906.

Guilford, J. P. and Karl M. Dallenbach. "The Determination of Memory Span by the Method of Constant Stimuli." American Journal of Psychology, XXXVI (1925), 621-628.

Kahn, Dale. "The Development of Auditory-Visual Integration and Reading Achievement." (unpub. Ph.D. dissertation, Columbia University, 1965).

Kass, Corrine E. "Psycholinguistic Disabilities of Children with Reading Problems." Exceptional Children, XXXII (1966), 533-539.

Kirk, Samuel A. and James J. McCarthy. The Illinois Test of Psycholinguistic Abilities: Experimental Edition. Urbana: Institute for Research on Exceptional Children, University of Illinois, 1961.

Kirk, Samuel A. and James J. McCarthy. The Illinois Test of Psycholinguistic Abilities. Urbana: University of Illinois Press, 1968.

Kirk, Samuel A., James J. McCarthy, and Winifred D. Kirk. Examiner's Manual Illinois Test of Psycholinguistic Abilities. Urbana: University of Illinois Press, 1968.

Marchbanks, Gabrielle and Harry Levin. "Cues by Which Children Recognize Words." Journal of Educational Psychology, LVI (1965), 57-61.

Muehl, Siegmar and Shirley Kremenak. "Ability to Match Information Within and Between Auditory and Visual Sense Modalities and Subsequent Reading Achievement." Journal of Educational Psychology, LVII (1966), 230-238.

Neville, Donald. "Learning Characteristics of Poor Readers as Revealed by the Results of Individually Administered Intelligence Tests," Vistas in Reading, Proceedings of the Eleventh Annual Convention, International Reading Association, 1966, Volume II, Part I. Newark, Delaware: International Reading Association, Inc., 1967.

Osgood, C. E. Contemporary Approaches to Cognition, A Behavioristic Analysis, Ed. J. S. Bruner. Cambridge: Harvard University Press, 1957.

Raymond, Dorothy MacLean. "The Performance of Reading Achievers on Memory Span and Associative Learning Tests." Journal of Educational Research, IIL (1955), 455-465.

Reynolds, Maynard C. "A Study of the Relationships Between Auditory Characteristics and Specific Silent Reading Abilities." Journal of Educational Research, XLVI (1953), 439-449.

Rizzo, Nicholas D. "Studies in Visual and Auditory Memory Span with Special Reference to Reading Disability." Journal of Experimental Education, VIII No. 2 (1939), 208-244.

Rose, Florence C. "The Occurrence of Short Auditory Memory Span Among School Children Referred for Diagnosis of Reading Difficulties." Journal of Educational Research, LI (1958), 459-464.

Rudisill, Mabel. "Flashed Digit and Phrase Recognition and Rate of Oral and Concrete Responses: A Study of Advanced and Retarded Readers in the Third Grade." The Journal of Psychology, XLII (1956), 317-328.

Rudnick, Mark, Graham M. Sterritt, and Mort Flax. "Auditory and Visual Rhythm Perception and Reading Ability." Child Development, XXXVIII (1967), 581-587.

Sandstedt, Barbara. "Relationship Between Memory Span and Intelligence of Severely Retarded Readers." The Reading Teacher, XVII (1964), 250-264.

Saunders, Margaret J. "The Short Auditory Span Disability." Childhood Education, VIII (1931), 59-65.

Sawyer, Rita I. "Does the Wechsler Intelligence Scale for Children Discriminate Between Mildly Disabled and Severely Disabled Readers?" The Elementary School Journal, LXV (1965), 97-103.

Sievers, Dorothy J. "Development and Standardization of a Test of Psycholinguistic Growth in Preschool Children." (unpub. Ph.D. dissertation, University of Illinois, 1955).

Sperling, George. "The Information Available in Brief Visual Presentations. Psychological Monographs, LXXIV. No. 11 (1960), 1-29.

Stauffer, Russell G. "Certain Psychological Manifestations of Retarded Readers." Journal of Educational Research, XLI, No. 6 (1948), 436-452.

Sterritt, Graham M. and Mark Rudnick. "Auditory and Visual Rhythm Perception in Relation to Reading Ability in Fourth Grade Boys." Perceptual and Motor Skills, XXII (1966), 859-864.

Wert, James E., Charles O. Neidt, and J. Stanley Ahmann. Statistical Methods in Educational and Psychological Research. New York: Appleton-Century-Crofts, Inc., 1954.

APPENDIX

APPENDIX A

THE FOUR CONSTRUCTED TESTS

AUDITORY MEMORY TEST

Items for this test were presented at the rate of two per second. Directions to the student were, "Say 9--4, etc."

9--4	6--9--4--2--7
8--9	7--4--8--2--3
8--3	2--7--3--4--8--5
5--2	7--9--6--8--9--3
8--2--6	2--9--6--4--1--9
1--5--9	5--7--9--6--2--9
9--2--7	5--7--2--6--8--1--3
7--3--8	7--1--5--1--8--2--6
6--4--2--9	7--3--2--5--1--9--1
1--8--4--7	9--5--7--3--8--5--2
3--5--8--4	1--6--9--4--8--5--8--3
9--2--7--2	5--2--8--2--6--1--5--9
1--9--5--6--5	9--2--7--3--8--5--1--8
3--1--5--8--7	7--3--5--3--8--4--9--2

VISUAL MEMORY TEST

Visual standards were presented in a hand operated tachistoscope. Directions to the student were: Look at this. (Standard for demonstration item A was presented.) Find one like it in the first row. Good. Draw a line through it. Slide your marker down to row one. (Show item one standard.) Mark your answer. (Show next item, etc.)

A.	GT	FT	PT	<u>BT</u>	CT	DT
1.	L	<u>K</u>	W	M	R	H
2.	r	v	n	<u>m</u>	w	u
3.	q	c	p	<u>g</u>	d	b
4.	m	<u>n</u>	u	w	v	r
5.	bl	lp	ld	pl	ql	<u>dl</u>
6.	vp	pw	dv	wd	qv	<u>pv</u>
7.	<u>jw</u>	jm	wg	wj	mj	jn
8.	<u>qh</u>	ph	hq	hd	dh	qn
9.	fbm	fqm	<u>fdm</u>	fbn	jpw	mdf
10.	bnx	bux	<u>bmx</u>	brx	bwx	bvx

11.	xam	xsm	xzm	xkm	xrm	xwm
12.	lfg	tlg	tgl	tfl	gtl	ltg
13.	mtx	tmx	mtk	tkm	mty	mfk
14.	tbq	tpb	tqb	tqd	tpd	tdp
15.	bfpq	dfpq	djbd	dpfq	djbq	dfpq
16.	rlsz	rzls	nslz	rslz	nlzs	rstz
17.	fzbp	fsdp	fzqd	fsqd	fzdp	fspb
18.	krbg	kndg	knbg	krdg	krpg	knpg
19.	bmld	bwid	bmid	bwld	blwd	bmld
20.	stnb	stwb	stmb	smtb	sntb	swtb
21.	fptw	ftqw	fqtw	ftpw	ftdw	fbtw
22.	xbhv	xhpv	xhbv	xphn	eqhv	xphv
23.	nxsjd	nsxjd	nxjsd	njsxd	nsjxd	nsjdx
24.	vnmhp	vrhmp	vmrhp	vmnhp	vrmhp	vhrmp
25.	lgrbs	lgnbz	lgrbz	lgndz	lgnbs	lgrsb
26.	wqzsp	wqzsd	wpszd	wqszd	wdszp	wqszp
27.	hwpls	hplws	hpwls	hwlps	hpwls	hplwz
28.	nspmb	npbsm	nspbm	npbms	nbzbm	npsbm

29.	wmvpf	wvmpf	wmvqf	wmvfp	wvmqf	wmvfq
30.	bpmzj	bpzmj	bqzmj	bpmzj	bqsmj	bpsmj
31.	sbjxvg	sjbxvg	sbxjvg	sjbvxg	sbvjxg	sjxbvg
32.	qmfbrg	qmfbgr	qmbfrg	qmfrbg	qmbfbr	qwfbrg
33.	stfrvl	slfrvt	slrfvt	strfvl	slvfrt	slvrft
34.	fkpmqj	fkqwpj	fkpwqj	fkbwdj	kfbmdj	fkqmpj
35.	cbgqmx	cgbqmx	cbqgmx	cbqgxm	cgqbmx	cqbgmx
36.	mgndxb	mgubxd	mgudxb	mgrbxd	mgnbxd	mgrdxb
37.	bnqphz	bngphs	bnqphs	bhgpnz	bhqpnz	bngphz
38.	xftqlj	xtfqlj	xtjqlf	xfjqlt	xftlqj	xtflqj

TEST OF AUDITORY-VISUAL INTEGRATION

For this test, auditory sound patterns were generated by a pure tone audiometer and tape recorded with the test directions. The following page contains the visual representations of the sound patterns, which are underlined, and the distractors for this test. These are the recorded test directions and auditory patterns presented to the children:

In this test, you will have to listen and look carefully. Slide your marker to row A on your answer sheet. Listen to these sounds. (. . presented in sound) You heard two short sounds close together. Now look at the first box in row A. Notice that it has two dots close together. It looks like two short sounds close together.

The second box has two dots with a big space in between. Listen to how these dots would sound. (.   . presented in sound) Now listen to these sounds. (. . . presented in sound) This was three dots close together. It was like the third box with the three dots close together. Place a mark in the third box with the three dots close together.

Now slide your marker to row B. Look up. Listen. (- . presented in sound) You heard a long sound followed by a short sound. You should place a mark in the second box which has a long mark followed by a dot. Place a mark in the second box.

Now slide your marker to row 1. Look up. Listen. (Sound pattern for item 1) Mark the correct answer. Slide to row 2, etc.

TEST OF AUDITORY-VISUAL INTEGRATION

A	. .	. .	. . .
B	. -	- .	. . -
1	. .	. .	. -
2	. -	- .	- .
3	- -	. .	- -
4	- .	- -	- .
5	. . .	. . .	. . .
6	- - -	. - -	- - -
7	- - .	. . -	- . -
8	. - .	. . -	. - .
9	. - -	- . -	- - .
10	- . -	- . -	- - .
11	. . . .	. . . .	. . . .
12	. . . .	. . . .	. . . .
13	. . - .	- . . .	- . . -
14	- . . -	- - . .	. - . .
15	. . . -	. . . -	. . . -
16	- . - -	- . - -	- . - -
17	. . - . .	. . - . .	. . - . .
18	-	-	- . . . .
19	. . . . .	. . . . .	. . . . .
20	. - . . -	. - . . -	. - . . -
21	- - - . .	- - - . .	- - - . .
22	- . . - -	- . . - -	- . . - -
23	. . . - .	. . . - .	. . . - .
24	-	-	- . . . .

TEST OF VISUAL-AUDITORY INTEGRATION

In this test the visual standard was presented first on a large card. The auditory patterns were recorded and followed the visual stimulus. Subjects decided whether the visual standard and the auditory pattern were the same or were different. An answer sheet was provided for recording the choice by marking a box. These were the tape recorded directions to the student:

Put your marker on the page so you can see row A. Look up to the front of the room. Look carefully at this card. (Pause of 5") Now listen. (Auditory pattern for example A was presented.) Was the sound the same as what you saw? It was the same, so you would put a mark in the first box in row A. Place a mark in the first box.

Now slide your marker to row B. Look up. Look. (Pause of 5") Listen. (Auditory Pattern for B) Were these the same? No, they were not. You should mark the second box, because they were different. Put a mark in the second box.

When what you see and hear are the same, put a mark in the first box. If they are different, put a mark in the second box. Are there any questions? (Tape recorder turned off to answer any questions)

Slide your marker to row 1. Look. (Pause 5") Listen. (Auditory pattern for row 1) Mark the first box if they were the same and the second box if they were different. Slide your marker to row 2, etc. (After five items, the directions about marking the answer sheet were changed to, "mark your answer.")

TEST OF VISUAL-AUDITORY INTEGRATION

	Visual	Auditory		Visual	Auditory
A	. .	. .	9	– . –	– . –
B	. –	– .	10	. . –	. – .
1	– .	– .	11	. . . .	. . . .
2	. .	. .	12	. . . .	. . . .
3	. –	– –	13	. . – .	. . – .
4	– .	. –	14	– . . –	– . – .
5	. . .	. . .	15	. . . –	. . . –
6	. . .	. . .	16	– . – .	– . – .
7	. – –	. – –	17	. . – .	. . – .
8	– – .	– – –	18	– – . –	– – . –

TEST OF VAI (continued)

	Visual	Auditory		Visual	Auditory
19	– . . – .	– . . . –	29	. – – . . .	. – . . . .
20	– . – – .	– . – – .	30	– – . . – .	– – . – . .
21	– – – . .	. – – . .	31	– – . . – .	– – . – – .
22	. . . . .	. . . . .	32	. . . – – –	. . . – – –
23	. . – . .	. . . – .	33	– . . . . –	– . – . . –
24	. . . . – .	. . . – .	34	. . – . – .	. . – . – .
25	. . . . –	. . . – .	35	. – – – . . –	. – – – . – .
26	. – – . –	. – – . –	36	– . . – . . –	– . . . – . –
27	– . . . . –	– . . . . –	37	. . – . – . .	. . – . – . .
28	. . – . – .	. . – . – .	38	. – . . – – .	. – . . – – .

APPENDIX B

MEAN RAW SCORES FOR GROWTH PATTERNS

MEAN RAW SCORES FOR GROWTH PATTERNS

Age Grade

Intervals	Number of cases	AM	VM	AVI	VAI
1.0--1.9	14	3.98	14.1	10.5	21.5
2.0--2.9	33	4.31	17.5	10.4	22.3
3.0--3.9	29	4.53	20.0	11.9	24.8
4.0--4.9	31	4.82	23.0	12.5	25.8
5.0--5.9	26	5.12	23.1	14.3	26.2
6.0--6.9	33	4.95	24.5	15.7	28.1
7.0--7.9	14	5.27	24.0	16.4	29.3

Mental Grade

Intervals	Number of cases	AM	VM	AVI	VAI
0.0--1.9	19	3.95	13.5	9.4	20.3
2.0--2.9	26	4.36	17.7	11.2	23.2
3.0--3.9	36	4.60	21.2	12.4	24.5
4.0--4.9	35	4.87	22.2	12.3	26.1
5.0--5.9	23	4.99	24.5	14.4	26.2
6.0--6.9	22	5.06	23.4	16.3	28.3
7.0--8.9	19	5.20	25.4	17.0	30.0

MEAN RAW SCORES (continued)

Oral Accuracy

Intervals	Number of cases	AM	VM	AVI	VAI
0--14	18	3.88	12.2	8.4	20.3
15--24	23	4.38	16.6	11.0	23.3
25--34	49	4.53	21.3	12.7	25.1
35--44	40	4.87	23.7	13.9	25.8
45--54	21	5.04	23.7	15.5	27.7
55--64	24	5.29	24.4	15.5	29.0
65--74	5	5.80	27.6	15.4	28.4

Oral Comprehension

Intervals	Number of cases	AM	VM	AVI	VAI
0--14	27	4.01	13.7	8.4	21.1
15--19	30	4.49	19.1	12.2	24.0
20--24	47	4.64	22.3	13.1	25.1
25--29	31	5.07	23.4	14.3	27.2
30--34	26	5.20	24.5	15.0	27.7
35--44	19	5.01	24.3	16.5	28.9

APPENDIX C

RAW DATA COLLECTED IN THIS STUDY

KEY FOR THE RAW DATA

The following key gives the meanings for the column headings in the listed raw data that was collected for each student:

1--the child's sex (boys are 1 and girls are 2)

2--the child's age grade with the decimal point omitted (22=2.2)

3--the child's mental grade with the decimal point omitted (22=2.2)

4--the Gilmore oral accuracy raw score

5--the modified Gilmore oral comprehension score

6--the child's IQ score from the <u>California Test of Mental Maturity</u>

7--the auditory memory raw score total (425=4.25). This is an equivalent to getting all four of the four digit series correct plus one of the five digit series.

8--auditory memory total of correct trials on odd items

9--auditory memory total of correct trials on even items

10--total correct on the visual memory test

11--total of odd items correct on the visual memory test

12--total of even items correct on the visual memory test

13--total correct on the test of AVI

14--total of odd items correct on the test of AVI

15--total of even items correct on the test of AVI

16--total correct on the test of VAI

17--total of odd items correct on the test of VAI

18--total of even items correct on the test of VAI

RAW DATA COLLECTED IN THIS STUDY

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
First	1	16	11	00	04	092	350	05	05	11	04	07	09	04	05	21	11	10
Grade	1	21	17	14	14	094	425	07	06	13	04	09	09	04	05	22	11	11
	1	20	16	15	12	094	400	06	06	12	06	06	05	03	02	23	11	12
	1	17	10	00	02	089	300	04	04	09	04	05	05	03	02	18	08	10
	1	23	25	05	10	103	450	07	07	19	10	09	10	02	08	22	10	12
	1	18	21	07	10	104	400	06	06	07	03	04	06	03	03	22	12	10
	1	16	17	09	12	102	375	06	05	10	05	05	13	07	06	23	12	11
	1	24	22	10	18	097	425	07	06	16	09	07	12	06	06	21	10	11
	1	22	22	04	10	100	475	07	08	11	06	05	06	03	03	20	08	12
	1	18	22	20	16	106	525	08	09	27	12	15	19	09	10	22	13	09
	1	21	22	17	14	101	400	06	06	12	06	06	06	03	03	24	14	10
	1	18	20	03	06	103	350	06	04	07	04	03	10	03	07	19	09	10
	1	20	17	25	16	096	400	06	06	24	10	14	16	07	09	18	11	07
	1	21	12	03	08	088	400	05	07	10	05	05	02	01	01	20	09	11
	1	18	15	03	09	095	475	08	07	19	09	10	11	06	05	23	11	12
	2	24	22	17	16	097	425	08	05	09	03	06	08	03	05	23	11	12
	2	23	16	03	06	090	325	04	05	19	09	10	10	05	05	21	10	11
	2	21	29	15	14	111	350	05	05	11	07	04	09	05	04	23	13	10
	2	20	21	04	07	102	325	04	05	17	08	09	07	04	03	13	08	05
	2	23	22	18	14	098	375	06	05	25	12	13	05	03	02	23	12	11
	2	21	15	21	15	092	400	06	06	12	06	06	11	05	06	12	06	06
	2	18	17	18	13	099	475	08	07	21	10	11	11	05	06	23	14	09
	2	17	21	25	18	106	450	07	07	19	08	11	14	07	07	28	13	15
	2	19	19	19	14	100	375	06	05	09	04	05	07	03	04	18	08	10
	2	23	16	04	08	090	425	07	06	08	03	05	06	04	02	19	11	08
	2	15	23	28	23	112	525	08	09	26	12	14	14	07	07	25	12	13
	2	22	24	17	19	103	550	09	09	21	09	12	13	05	08	26	15	11
	2	18	17	04	13	098	300	04	04	11	06	05	10	06	04	24	10	14
	2	20	11	14	14	093	475	08	07	15	06	09	06	03	03	19	07	12
	2	16	08	00	02	088	275	03	04	07	04	03	08	04	04	14	10	04

RAW DATA (continued)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Second Grade	1	26	19	30	09	091	450	07	07	10	03	07	07	02	05	17	09	08
	1	32	42	23	22	112	500	08	08	18	08	10	11	05	06	22	13	09
	1	42	36	10	13	093	425	06	07	10	05	05	11	04	07	25	13	12
	1	38	29	23	20	090	425	06	07	19	09	10	13	06	07	23	10	13
	1	30	28	15	19	098	325	05	04	12	05	07	11	07	04	20	11	09
	1	29	32	19	21	104	450	07	07	19	11	08	15	06	09	25	12	13
	1	26	27	27	19	101	350	05	05	22	12	10	13	08	05	17	09	08
	1	28	35	33	21	109	425	06	07	22	11	11	10	04	06	24	12	12
	1	24	19	28	17	093	425	05	08	15	06	09	11	04	07	25	13	12
	1	34	37	27	26	104	400	05	07	24	13	11	13	05	08	20	10	10
	1	28	24	22	15	095	450	07	07	20	10	10	13	05	08	30	17	13
	1	34	38	27	14	105	475	08	07	27	13	14	10	04	06	20	10	10
	1	24	34	31	21	114	450	07	07	29	14	15	14	07	07	26	13	13
	1	27	34	34	21	109	475	08	07	20	10	10	14	06	08	23	10	13
	1	26	22	19	16	095	475	07	08	08	04	04	09	05	04	20	10	10
	2	31	31	34	20	100	400	06	06	20	11	09	10	06	04	23	15	18
	2	27	24	35	18	096	500	08	08	21	09	12	15	07	08	25	12	13
	2	30	30	18	18	100	500	07	09	17	07	10	17	07	10	29	13	16
	2	28	28	37	18	100	450	07	07	25	12	13	12	05	07	32	18	14
	2	28	33	28	25	109	475	08	07	25	12	13	18	09	10	31	14	17
	2	31	28	32	19	096	475	07	08	22	10	12	19	09	10	28	14	14
	2	28	23	33	22	094	475	07	08	16	07	09	12	07	05	24	13	11
	2	24	23	41	25	098	425	06	07	27	15	12	13	07	06	27	14	13
	2	32	39	36	23	109	450	07	07	23	11	12	14	06	08	23	11	12
	2	33	32	31	20	099	525	08	09	18	08	10	14	07	07	22	11	11
	2	31	27	16	18	095	450	08	06	21	11	10	08	02	06	27	15	12
	2	33	34	34	23	101	475	07	08	19	08	11	08	04	04	25	12	13
	2	25	25	27	16	100	500	08	08	19	10	09	15	07	08	19	09	10
	2	24	30	33	24	108	425	07	06	24	12	12	09	06	03	23	10	13
	2	34	32	30	24	098	400	06	06	12	06	06	09	05	04	31	15	16

RAW DATA (continued)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Third Grade	1	39	37	22	17	098	475	08	07	14	07	07	08	02	06	24	11	13
	1	44	52	42	30	108	475	08	07	26	11	15	15	06	09	23	11	12
	1	39	47	31	22	109	500	08	08	24	12	12	14	05	09	31	18	13
	1	43	38	38	28	095	525	09	08	20	08	12	16	06	10	28	15	13
	1	39	34	46	24	094	475	07	08	19	09	10	15	07	08	20	11	09
	1	38	35	42	25	097	500	08	08	26	13	13	09	05	04	22	09	13
	1	43	42	26	15	099	400	06	06	17	07	10	11	04	07	22	13	09
	1	35	42	59	28	108	475	07	08	24	11	13	11	04	07	23	11	12
	1	43	39	37	24	096	425	07	06	22	09	13	14	07	07	22	14	08
	1	37	34	27	20	096	375	06	05	19	09	10	10	02	08	18	09	09
	1	39	43	37	21	104	500	07	09	22	11	11	12	05	07	28	13	15
	1	34	41	15	15	108	425	06	07	14	07	07	12	04	08	29	15	14
	1	39	35	17	14	096	375	06	05	17	08	09	14	06	08	26	11	15
	1	42	36	31	19	094	425	06	07	19	11	08	11	03	08	23	13	10
	1	36	33	33	22	096	400	06	06	23	11	12	11	05	06	21	09	12
	2	36	34	31	18	098	450	06	08	20	11	09	09	04	05	24	10	14
	2	43	43	45	27	100	525	09	08	21	11	10	13	04	09	28	14	14
	2	42	41	30	25	099	400	05	07	22	10	12	08	05	03	29	16	13
	2	42	37	35	23	095	450	07	07	26	12	14	13	08	05	21	12	09
	2	43	38	28	17	095	475	08	07	25	13	12	12	05	07	24	13	11
	2	38	42	44	30	104	400	06	06	20	08	12	11	04	07	26	15	11
	2	42	43	33	25	101	500	08	08	23	11	12	15	07	08	26	14	12
	2	37	35	34	24	098	450	06	08	22	12	10	13	07	06	28	15	13
	2	40	43	38	24	103	475	08	07	25	12	13	13	08	05	31	17	14
	2	38	37	32	23	099	425	06	07	21	10	11	13	07	06	27	14	13
	2	42	35	36	22	092	475	08	07	26	12	14	06	04	02	17	10	07
	2	39	43	48	31	105	600	10	10	26	14	12	15	06	09	27	09	18
	2	48	42	28	23	094	475	07	08	19	10	09	10	05	05	26	14	12
	2	37	47	52	25	112	475	08	07	17	07	10	12	08	04	32	16	16
	2	41	40	37	25	099	500	08	08	24	12	12	15	08	07	28	17	11

RAW DATA (continued)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Fourth Grade	1	51	40	30	13	089	600	09	11	22	11	11	13	05	08	27	17	10
	1	49	39	45	27	090	600	10	10	22	11	11	13	06	07	25	12	13
	1	44	37	56	23	093	400	06	06	21	09	12	10	02	08	24	11	13
	1	48	37	59	33	089	500	08	08	26	12	14	18	08	10	30	13	17
	1	50	47	41	21	097	450	07	07	29	13	16	11	04	07	23	13	10
	1	52	47	55	31	095	575	10	09	24	13	11	16	07	09	31	13	18
	1	52	40	37	21	088	425	07	06	21	10	11	12	07	05	27	12	15
	1	50	42	37	23	092	525	09	08	22	09	13	12	05	07	26	15	11
	1	52	49	29	21	097	475	08	07	25	13	12	12	07	05	26	13	13
	1	53	42	37	21	089	400	05	07	22	10	12	17	08	09	22	10	12
	1	51	55	36	24	104	525	09	08	22	10	12	11	03	08	22	11	11
	1	48	44	44	29	096	475	07	08	26	12	14	08	02	06	22	11	11
	1	53	53	43	34	100	650	11	11	23	10	13	13	08	05	28	15	13
	1	48	56	50	25	108	425	07	06	25	11	14	13	05	08	28	13	15
	1	49	49	45	32	100	575	10	09	28	15	13	09	03	06	27	13	14
	2	48	61	31	22	113	400	07	05	22	10	12	14	06	08	22	12	10
	2	53	44	44	31	091	425	07	06	23	10	13	13	06	07	22	15	07
	2	56	50	22	22	094	500	07	09	22	09	13	15	06	09	21	09	12
	2	49	49	28	19	100	500	09	07	24	12	12	09	03	06	27	12	15
	2	50	42	40	28	092	425	06	07	21	11	10	09	02	07	21	11	10
	2	52	43	37	28	091	675	11	12	19	08	11	11	05	06	23	10	13
	2	50	49	29	22	099	450	07	07	14	05	09	15	05	10	31	17	14
	2	47	49	44	25	102	575	09	10	30	15	15	18	08	10	30	15	15
	2	47	56	46	25	109	625	10	11	27	14	13	13	05	08	31	15	16
	2	53	59	34	25	106	500	08	08	19	09	10	19	08	11	26	13	13
	2	51	43	35	27	092	525	08	09	21	09	12	12	04	08	24	13	11
	2	47	43	41	18	096	500	08	08	26	13	13	13	06	07	22	10	12
	2	46	38	35	18	092	375	05	06	17	08	09	15	05	10	24	10	14
	2	49	39	26	16	090	475	07	08	25	11	14	11	06	05	28	13	15
	2	48	62	34	22	114	450	07	07	20	10	10	12	05	07	25	12	13

RAW DATA (continued)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Fifth	1	62	56	44	27	095	525	08	09	29	15	14	17	08	09	28	16	12
Grade	1	68	63	31	23	096	400	07	05	23	11	12	18	08	10	26	13	13
	1	62	68	60	32	105	675	11	11	29	13	16	08	04	04	24	14	10
	1	64	62	41	27	098	475	07	08	18	07	11	17	09	08	32	16	16
	1	60	61	51	35	101	500	08	08	22	10	12	15	06	09	33	18	15
	1	61	53	25	19	093	450	06	08	22	09	13	13	07	06	26	13	13
	1	55	71	55	30	115	450	08	06	27	14	13	14	07	07	27	14	13
	1	60	44	46	38	085	375	05	05	20	10	10	14	05	09	22	12	10
	1	43	34	59	26	090	750	14	12	25	11	14	17	06	11	36	18	18
	1	67	54	48	30	089	500	08	08	26	13	13	13	07	06	25	12	13
	1	65	64	34	23	099	525	09	08	26	13	13	14	06	08	32	16	16
	1	63	66	43	33	103	425	06	07	26	14	12	15	09	06	29	14	15
	1	53	60	51	28	107	625	10	12	27	11	16	21	10	11	30	15	15
	1	60	58	40	23	098	500	08	08	26	11	15	16	07	09	22	10	12
	1	61	59	21	23	098	450	06	08	22	11	11	13	05	08	23	13	10
	2	54	44	41	22	087	500	08	08	25	12	13	17	08	09	28	17	11
	2	62	70	43	35	107	425	06	07	23	11	12	15	06	09	25	14	11
	2	55	59	62	30	104	600	10	10	28	12	16	16	06	10	29	16	13
	2	57	61	44	34	104	600	10	10	19	09	10	17	06	11	28	14	14
	2	48	55	51	37	107	375	05	06	24	11	13	12	06	06	25	13	12
	2	56	58	33	23	102	425	06	07	29	13	16	15	07	08	25	15	10
	2	60	74	61	29	113	550	09	09	25	12	13	16	08	08	27	12	15
	2	55	64	55	38	109	425	06	07	25	11	14	17	07	10	30	17	13
	2	58	67	58	35	109	625	10	11	23	10	13	20	10	10	28	14	14
	2	56	46	26	19	091	450	06	08	20	12	08	06	01	05	24	14	10
	2	67	75	59	36	112	475	08	07	21	10	11	14	07	07	33	16	17
	2	56	58	62	30	102	475	07	08	28	12	16	19	08	11	31	17	14
	2	63	52	44	34	090	500	09	07	24	11	13	15	06	09	30	15	15
	2	65	56	44	28	092	425	06	07	25	13	12	17	09	08	27	15	12
	2	63	77	56	22	113	525	08	09	25	12	13	21	09	12	30	14	16

RAW DATA (continued)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Sixth	1	77	90	56	34	110	475	07	08	26	10	16	15	04	11	31	14	17
Grade	1	72	56	47	31	087	450	07	07	21	10	11	21	11	10	26	14	12
	1	74	58	41	26	087	450	06	08	20	10	10	14	05	09	26	13	13
	1	69	63	58	31	095	475	08	07	20	10	10	13	04	09	23	11	12
	1	66	57	51	33	092	425	08	05	27	12	15	16	07	09	29	15	14
	1	73	57	58	34	087	650	10	12	22	11	11	12	06	06	28	13	15
	1	71	72	54	32	101	425	06	07	22	11	11	16	08	08	26	16	10
	1	72	60	40	27	090	475	07	08	24	11	13	20	10	10	31	16	15
	1	66	65	47	35	099	500	08	08	23	11	12	19	09	10	30	15	15
	1	68	57	65	28	091	575	09	10	27	14	13	09	01	08	26	13	13
	1	68	67	72	39	099	575	10	09	25	11	14	15	06	09	27	13	14
	1	72	81	70	40	107	550	09	09	27	12	15	15	07	08	29	14	15
	1	68	73	31	23	104	475	06	09	23	12	11	16	08	08	30	18	12
	1	71	66	32	24	096	525	09	08	22	11	11	12	05	07	29	16	13
	1	66	64	57	32	098	600	11	09	28	12	16	16	07	09	28	15	13
	2	67	81	45	33	112	525	09	08	21	11	10	17	08	09	33	17	16
	2	72	82	49	32	108	600	09	11	22	10	12	20	09	11	23	12	11
	2	73	80	57	35	106	575	09	10	22	11	11	19	10	09	33	18	15
	2	69	77	56	42	107	475	07	08	27	14	13	14	05	09	33	17	16
	2	68	70	32	28	102	450	07	07	22	10	12	17	06	11	28	15	13
	2	73	84	56	31	109	475	07	08	26	11	15	17	07	10	36	19	17
	2	72	89	68	38	114	600	10	10	30	14	16	19	08	11	30	13	17
	2	65	51	59	35	088	450	07	07	20	09	11	14	08	06	23	12	11
	2	69	69	54	40	100	425	06	07	28	14	14	22	10	12	30	18	12
	2	77	67	61	37	092	500	08	08	14	06	08	18	09	09	30	13	17
	2	72	84	54	38	110	550	10	08	30	17	13	17	06	11	31	19	12
	2	67	69	34	25	102	400	06	06	21	10	11	19	08	11	28	17	11
	2	73	69	61	36	097	525	07	10	29	15	14	16	07	09	27	16	11
	2	68	86	66	37	115	600	10	10	29	14	15	19	09	10	30	16	14
	2	68	82	42	21	112	675	12	11	34	15	19	22	10	12	35	18	17

APPENDIX D

CORRELATIONS BETWEEN ODD AND EVEN ITEMS, COEFFICIENTS OF RELIABILITY, AND STANDARD ERRORS OF THE FOUR CONSTRUCTED TESTS AT EACH GRADE LEVEL

CORRELATIONS BETWEEN ODD AND EVEN ITEMS, COEFFICIENTS OF RELIABILITY,

AND STANDARD ERRORS OF THE FOUR CONSTRUCTED TESTS

Grade	Correlations Odd and Even	Coefficients of Reliability	Standard Errors	Correlations Odd and Even	Coefficients of Reliability	Standard Errors
	Auditory Memory			Auditory-Visual Integration		
1st	.41	.59	2.98	.69	.81	2.23
2nd	.68	.81	1.92	.63	.78	2.69
3rd	.70	.82	2.60	.81	.89	2.05
4th	.75	.86	2.30	.63	.78	2.79
5th	.69	.82	3.06	.74	.85	2.66
6th	.72	.84	2.83	.65	.79	2.92
	Visual Memory			Visual-Auditory Integration		
1st	.50	.66	3.46	.60	.75	2.87
2nd	.68	.81	2.64	.68	.81	2.55
3rd	.70	.82	2.37	.78	.88	2.53
4th	.84	.91	1.91	.80	.89	2.34
5th	.69	.81	3.10	.63	.78	3.33
6th	.77	.87	2.70	.68	.81	3.17

VITA

Leo Vincent Rodenborn, Jr.

Candidate for the Degree of

Doctor of Education

Thesis: AN EXAMINATION OF THE IMPORTANCE OF AUDITORY-VISUAL INTEGRATION, VISUAL-AUDITORY INTEGRATION, AUDITORY MEMORY, AND VISUAL MEMORY TO ORAL READING

Major Field: Elementary Education

Biographical:

Personal Data: Born at Ford Dodge, Iowa, May 16, 1932, the son of Leo V. and Margaret R. Rodenborn.

Education: Attended elementary and secondary schools in Fort Dodge, Iowa; graduated from Fort Dodge Senior High School in 1949; received the Bachelor of Arts degree from the University of Northern Iowa at Cedar Falls, with a major in secondary education, in June, 1959; received the Master of Science degree from the Oklahoma State University, with a major in secondary education, in May, 1966; completed requirements for the Doctor of Education degree in August, 1969.

Professional Experience: Entered the United States Air Force in 1951 and was discharged in 1955 with the rank of A/1C; taught junior high social studies and English at Sibley, Iowa, 1959-1963; taught eighth grade English, social studies, and reading at Iowa Falls, Iowa, 1963-1965; served as a graduate assistant at Oklahoma State University during the fall semester 1965; taught high school remedial reading at Pawnee, Oklahoma, during the spring of 1966; served as a reading specialist and coordinator of a county remedial reading program under Title III at Osage County, Oklahoma, 1966-68; served as visiting professor at Oregon College of Education, Monmouth, Oregon, summer of 1967, served as an adjunct professor teaching extension classes in diagnosis and treatment of reading problems at Oklahoma State University, 1967-68; served as an instructor supervising a reading practicum during the summer of 1968; served as a three-fourth time instructor at Oklahoma State University, 1968-69; recently appointed to the faculty of the University of Missouri--St. Louis as an assistant professor.

Publications: Co-author with Dr. Darrel D. Ray of the Reading Record File and the Readiness Record File, published by Diagnostic Publishing Co.; author of an article in the Oklahoma Reader entitled: "What Is Remedial Reading?", published in November, 1968.