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A COMPARISON OF VISUAL AND AUDITORY SEQUENCING IN GOOD AND POOR READERS IN GRADES TWO AND SIX.

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by

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ABSTRACT

The present study was conducted to determine the relative proficiency of auditory sequencing as compared to visual sequencing in school-age children, and to examine possible differences in these skills in poor as compared to good readers. Thirty-two second-grade and 32 sixth-grade Ss, half of whom were good readers and half of whom were poor readers, were matched for age and WISC prorated PIQ. They were presented with equivalent verbal sequences, which varied in complexity, through the visual and auditory channels. Half of the Ss received the visual task first and the auditory task two days later, while the other half received the auditory task first and the visual task second.

The results indicated that all Ss performed faster on the auditory task than on the visual task, regardless of order of presentation or level of complexity. The results also indicated that the younger poor readers made more errors than the younger good readers on both tasks, but particularly on the auditory task; the performances of the older poor and good readers, in general, did not differ. These results were discussed in conjunction with previous findings and in the context of their relevance to reading instruction.

PREFACE

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CHAPTER 1

INTRODUCTION

Although reading material is represented by a visual symbol system, learning to read requires something more than visual perception alone. There is considerable evidence to suggest that, in addition to several other non-visual skills, auditory perception is also very important for acquiring reading ability. Myklebust and Johnson (1962), who have placed particular emphasis on the auditory modality, have defined reading as "... a visual-symbol system superimposed upon a previously acquired auditory language system." Fries (1963) defined reading quite similarly, and went on to develop a step-by-step task analysis of the individual components involved in matching the visual signal to the auditory signal. The view of Gibson (1969) is essentially quite similar. From this point of view, the possession of adequate auditory-perceptual skills is a prerequisite. For example, children who have deficiencies in such auditory-perceptual skills as discrimination and sequencing might be expected to have difficulty in learning to read. Similarly, deficiencies in similar visual-perceptual skills might interfere with learning to read.

It is not surprising, therefore, that studies in the area of specific reading disability reveal a predominance

of deficits in these and other perceptual skills, such as auditory-visual integration and perceptual speed, in poor readers as compared to good readers. In fact the presence of relatively poorer visual- and auditory-perceptual skills in children with reading difficulties as compared to normal readers has been clearly established (e.g., Johnson, 1957; Goins, 1958; Birch & Belmont, 1964; Gibson, 1965; Doehring, 1968).

It is quite clear from this body of research that both visual- and auditory-perceptual factors are consistently among the strongest of those factors which discriminate between good and poor readers. But, despite the ever-increasing number of studies exploring visual and auditory perception in poor readers, the question of the relative importance of each modality in reading acquisition in this group of children has received little attention.

There is evidence that in normal populations of children the auditory modality is more effective than the visual for recalling lists of words (e.g., Hawkins, 1897; Pohlman, 1906), and for learning paired-associate words (e.g., Budoff & Quinlan, 1964). There is also considerable evidence to suggest that listening to a story results in greater recall than in reading it for younger children, but that reading becomes increasingly more effective with

age until, at approximately age 12, reading becomes superior and tends to remain so thereafter (e.g., Russell, 1921; Day & Beach, 1950; McGeoch & Dillon, 1952; Many, 1955; Durrell, 1969). Conversely, visual learning is superior to auditory learning of nonsense syllables (e.g., Pohlman, 1906; Lenhard & Sidowski, 1961; Cooper & Gaeth, 1967).[1] Thus, there is evidence that, in normal populations, the visual modality is more effective than the auditory for processing non-verbal, unfamiliar and less-meaningful material at all ages. There is also evidence that, for familiar and meaningful verbal material, the auditory modality is more effective in younger children, but that the visual modality becomes increasingly more effective with advancing age.

Although it is quite clear that poor readers, particularly at younger ages, perform more poorly than do good readers on most perceptual tasks, the relationships described above have not been adequately demonstrated in poor readers and, in fact, there is reason to expect some differences in this group. Hence, the following question can be raised. Is there a characteristic difference in the relative proficiency of visual and auditory processing in poor as compared to good readers?..and is this a function of age?

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1. For a review of this and the following literature see Appendix A.

The views of Myklebust and Johnson (1962) and Fries (1963) with regard to what reading entails may provide some relevant considerations related to this question. The essential feature of this approach to the analysis of reading is that learning to read requires the ability to make a spatial sequence of visual symbols (graphemes) correspond to an already-learned temporal sequence of sounds (phonemes). The visual skill that is required is a new skill to be learned. However, the auditory skill required has already been learned, having been practiced since a very early age during the course of early language development. This model would predict that deficiencies in either visual perception or auditory perception or visual-auditory integration might hinder reading acquisition. All of these skills have been found to be deficient in poor readers. While each of these skills is undoubtedly important, it would seem that auditory perception in particular would be critical, since it is the referent or comparison element in this process. It may well be, therefore, that auditory perception in particular is deficient in poor readers.

While there has been very little research directly comparing visual- and auditory-perceptual skills in poor readers, there is some evidence to suggest that several auditory-perceptual abilities may indeed be impaired to

a greater degree than are comparable visual-perceptual abilities. For example, in the perception of non-verbal sequential material the visual modality is clearly superior to the auditory in poor readers as well as good readers on matching tasks (Meuhl & Kremenak, 1966) and on sequential recall tasks (Fillmer & Linder, 1970). On the other hand, Walters and Kosowski (1963) found that, while poor readers performed as well as good readers on a visual reaction-time task, they were clearly poorer than the good readers on an auditory reaction-time task. Similarly, in a study by Katz (1967), while poor readers performed more poorly than good readers on both visual and auditory discrimination tasks involving familiar (English), and unfamiliar (Hebrew) words, the difference between the two groups in auditory discrimination was greater than the difference in visual discrimination. There is some reason to suspect that this may apply in the case of older children as well as younger children. For instance, Rourke, Orr and Ridgely (1974) found that poor readers differed from good readers to a somewhat greater extent on auditory-perceptual tests than on visual-perceptual tests, even at the age of 11. Additionally, in a clinical setting, the present author has repeatedly noted that the performance of older (11- and 12-year-old) children who have severe reading difficulties tends to be more impaired

on auditory-perceptual tests than on tests measuring visual-perceptual skills.

There is evidence that the difference between good and poor readers on both visual and auditory tests is greater at younger ages (6 to 8 years), (e.g., Katz & Deutsch, 1964; Reed, 1958; Rourke, Orr & Ridgely, 1974), suggesting that deficient perceptual skills may be of primary importance in determining reading disability at the earlier stages of reading instruction. Deficiencies in higher-order skills (e.g., symbolic processing; conceptual skills) may be more important at later ages (e.g., Satz, Rardin & Ross, 1971).

Although these relationships are by no means established, there does appear to be both theoretical and empirical support for the view that there are some differences between good and poor readers in the relative proficiency of auditory as compared to visual perception. Unfortunately, much of the research in this area does not facilitate a clear understanding of these relationships because of several factors, including the following: small sample sizes; the use of highly specific populations; and, particularly, the questionable "equivalence" between the auditory and visual tasks.

The aim of the present investigation was to explore these relationships by presenting equivalent stimuli which vary in complexity, familiarity, and meaningfulness, through

the visual and auditory channels to good and poor readers at two different age levels. Only boys were included, since a considerable sex difference in the number of children with reading difficulties has been reported (e.g., Lerner, 1971). The perceptual task chosen is one which involves speed of perception for sequential, verbal material. More specifically, the task is an adaptation of the Speed of Visual Perception Test (Doehring, 1968). This test consists of 13 individual subtests involving verbal and non-verbal stimuli which vary in complexity, familiarity, and meaningfulness. The stimuli include individual nonsense-forms, gestalt forms, individual numbers and letters, sequences of geometric forms, and sequences of letters. On each subtest the subject is required to find a particular stimulus or stimulus configuration on a page which is filled with lines of related stimuli, and to underline it as quickly as possible. The correct stimulus appears randomly throughout the series. For instance, on one subtest, various single letters of the alphabet are arranged randomly on a page, 20 letters to a line, 18 lines to a page. On this subtest the subject must underline all of the instances of the letter, "s," as quickly as he can. On another subtest the correct stimulus is a four-letter unit such as "narp," while the other stimuli consist of various combinations of the same four letters

(i.e., prna, npra, etc.). On each subtest, a sample of the correct stimulus is given at the top of the page. A preliminary test is given which consists of an illustration of the stimulus to be identified, an example of a sequence of test items in which the correct stimulus is underlined, and a short series of practice items. Examples of the 13 subtests taken from Dudley, Doehring, and Coderre (1968), with the correct items underlined, are contained in Appendix B.

For the present investigation, while many of the basic components of the test were preserved, the test was altered considerably to allow for both a visual and an auditory presentation. For obvious reasons, the non-verbal subtests (2, 3, 4, & 8) were deleted. Subtests 6 and 12 were also deleted because of the nature of the response. Subtests 1 and 13 (which are essentially the same) were deleted to further reduce the total time of the test. This was done because in the present study the type of response required involves a considerable amount of vigilance which (as was seen in pilot work) could result in early inattention and fatigue, particularly in the younger children. One subtest was added in order to increase the amount of familiar or meaningful material. In all, six subtests were employed. The visual stimuli were presented on film; the auditory materials

were presented by means of a tape recorder. Instead of an underlining response, the subjects were required to press a lever to indicate their recognition of the correct stimulus. Response latency and number of errors were measured. A full description of the test is given in the Method section. Examples of the six subtests with the correct stimuli underlined are contained in Appendix C.

This test was adapted for the present investigation for several reasons: (1) because of its demonstrated high association with reading ability (Doehring, 1968; Ridgely & Rourke, 1971; Rourke, Orr & Ridgely, 1974); (2) because it involves a combination of several perceptual skills, including attention, memory, discrimination, sequencing, and speed of recognition; (3) because the individual subtests vary in complexity, familiarity, and meaningfulness; and (4) because it allowed for a fairly straightforward translation to an equivalent auditory presentation.

A lever-pressing response was selected because it allowed for accurate timing and recording, and also because it is less difficult than a verbal response, particularly for the poor readers. A lever-pressing response was employed successfully by Spring (1971) for measuring perceptual speed in a letter discrimination task. He required his subjects to press one lever if the

letters were the same and another lever if they were different. In the present investigation, only one lever was used, with a response-no-response choice, since the stimuli in most instances were more complex. This being the case, a two-choice response could be confusing, particularly for the younger children who frequently have difficulty in right-left orientation.

The hypotheses of the present study were concerned with two separate, though related, questions: (I) the relative proficiency of auditory as compared to visual sequencing in younger and older school-aged children; and (II) possible characteristic differences in the relative proficiency of these abilities in poor readers as compared to good readers at these two age-levels.

Hypothesis Ia Speed and accuracy of auditory sequencing will be superior to speed and accuracy of visual sequencing of familiar and meaningful material (subtests 5 & 6) for younger children, but not for older children.

Hypothesis Ib Speed and accuracy of visual sequencing will be superior to speed and accuracy of auditory seqencing of unfamiliar and less meaningful material (subtests 3 & 4) for all children.

Hypothesis Ic There will be no differences in speed and accuracy of visual and auditory perception of single-letter stimuli (subtests 1 & 2) at each age level.

Hypothesis Id Older children will perform faster and more accurately than younger children on both the visual and auditory tasks.

Hypothesis IIa In both speed and accuracy of visual and auditory perception, the performance of the younger good readers will exceed that of the younger poor readers on the four-letter stimuli. This difference will be greater for the auditory task.

Hypothesis IIb In speed and accuracy of visual sequencing, the performance of the older good and poor readers will not differ, but the poor readers will be slower and less accurate than the good readers on the auditory task.

CHAPTER II

METHOD

SUBJECTS

Thirty-two good readers and 32 poor readers were selected from grade 2 and grade 6 classes in the Windsor school system on the basis of their centile scores on the Word Knowledge and Reading subtests of the Metropolitan Achievement Test (MAT). There were 16 boys in each reading group from each grade. The groups were equated for age and prorated Performance IQ (PIQ) on the Wechsler Intelligence Scale for Children (WISC). All Ss could recognize and name all the letters of the alphabet. Children with serious vision or hearing problems were excluded.

Reading Level

The Word Knowledge and Reading subtests of the MAT were administered to all boys in grade 2 and grade 6 classes in four relatively large schools whose populations were fairly homogeneous socio-economically. The children were tested in small groups (seldom exceeding 20) by the investigator. He was sometimes assisted by another adult when the younger children were being tested. In most instances, the testing was done in "spare" classrooms, but

in some instances the children were tested in their own classrooms, the teacher not being present. In all, approximately 240 children received the reading test. Those whose centile scores on the Word Knowledge and Reading subtests exceeded 60 were assigned to the good-reading groups. Those who obtained a centile score of 50 or below on the Word Knowledge subtest and 30 or below on the Reading subtest were assigned to the poor-reading groups.

Age

Children in grade 2 were included if they were between the ages 7 and 8, and children in grade 6, if they were between the ages of 11 and 12 at the time the reading test was taken.

IQ and Knowledge of the Alphabet

Prior to taking the IQ test, each child was required to demonstrate his knowledge of the letters of the alphabet. The examiner had two cards on which the letters were printed in different random orders. First, the child was required to point to each letter on one of the cards, as the examiner said them, according to a predetermined order. Then he was required to name all the letters on the second card. If he made any errors in either recognizing or naming the letters, the task was repeated. If he continued to make errors, particularly if he reversed or

inverted letters, he was excluded. This occured for only two children; both were in grade 2 and both were good readers.

A short form of the WISC was then administered individually by the investigator or by one of two assistants who had extensive experience in administering this test. This test was administered either in "spare" classrooms or in smaller "utility" rooms within the respective schools. The short form of the WISC consisted of the Picture Arrangement, Block Design and Object Assembly subtests. The five "verbal" subtests and the Coding subtest were not included since a relationship between these subtests and reading ability has been demonstrated (e.g., McLeod, 1965; Richardson, 1956). The Picture Completion subtest was excluded because of the verbal response required. PIQ scores were prorated for the three subtests using the standard formula for prorating. Children whose prorated PIQ scores fell below 90 or above 118 were excluded.

Vision and Hearing Problems

In the letter requesting permission for the children to participate in the study, the parents were asked to report any serious vision or hearing problems of which they were aware that might affect their child's visual

or auditory acuity. Such problems as hearing loss in one or both ears, or poor visual acuity in one or both eyes were reported occasionally. Children with such problems were excluded.

MATERIALS AND APPARATUS

Both the visual and the equivalent auditory adaptations of Doehring's (1968) Speed of Visual Perception Test consist of six subtests. Each subtest consists of 15 stimuli or stimulus configurations, only five of which are the correct ones.

Subtest 1. A series of 15 letters with the correct stimulus, s, placed randomly and appearing or being heard five times in the series.

Subtest 2. A series of 15 letters with the correct stimuli, b or m, appearing or being heard three and two times respectively in the series.

Subtest 3. A series of 15 four-letter units composed of various sequential combinations of the letters, b, f, m, and s, with the correct sequence, fsbm, appearing or being heard five times in the series.

Subtest 4. A series of 15 sequential combinations of the letters, a, n, p, and r, with the correct sequence, narp, appearing or being heard five times in the series.

Subtest 5. A series of 15 sequential combinations of

the letters, o, p, s, and t, the correct sequence, spot, appearing, or being heard five times in the series.

Subtest 6. A series of 15 sequential combinations of the letters, e, n, s, and t, with the correct sequence nest, appearing, or being heard five times in the series.

The Speed of Visual Perception Test

The visual adaptation of the test (hereafter called the SVPT) was accomplished by means of a 16 mm black and white movie film (Kodak Tri-X). Employing an animation technique, single frame shots of the individual stimuli were taken using a Bolex Rex movie camera (model 816).

The stimuli (lower case letters) were carefully printed, one in high, on strips of white construction paper, using a thick, black marking pen. The background for the stimuli consisted of a 7 in X 11 in piece of white construction paper in which was cut a small 2 in X 1¼ in window. The stimuli were mounted behind the paper in such a fashion that they could be made to appear through the small window. Surrounding the white background was a larger 15 in X 20 in piece of black construction paper. This whole unit was mounted on a wall, while the movie camera was mounted on a tri-pod 4 feet from the wall during the filming.

Each letter was shot on 8 successive frames of film. The four-letter units required 32 frames, 8 frames per

letter. The four-letter units, (e.g., fsbm) were filmed so that they would appear on the screen in a spatial- and temporal-sequential fashion, i.e., the f appeared in the first position on 8 frames and then disappeared, followed immediately by the s in the second position on 8 frames, the b in the third position, and the m in the fourth position. Preceeding each stimulus unit were 16 exposed frames on which no stimulus appeared; this allowed for a preparatory interval (PI). Following the last letter in each stimulus unit were 64 unexposed frames; this allowed for an inter-stimulus interval (ISI). Graphic illustrations of sections of film are contained in Appendix D.

In the test situation the film was projected on an 18 in X 24 in screen (oil painting canvas) by means of a Bell and Howell projector (model 556). When seen on the screen, the letters measured approximately 1½ in high. The particular projector used in the present study had a silent film speed of approximately 22.500 frames per sec[2], so that individual frame time was 0.045 sec.

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2. Film speed was calculated by the E using the Hunter digital counter employed in the present study for counting the latency of response. The manufacturer of the projector lists the silent film speed as 18 frames per sec. There are several possible explanations for this discrepency, such as wear of the mechanical parts, variation in motor speed, etc. It is also possible that the counter was inaccurate, although this is less likely, since this instrument was checked against a stop-watch.

Consequently, viewing time for an individual letter was 0.360 sec, for a four-letter sequence, 1.440 sec, for the PI, 0.730 sec, and for the ISI, 2.880 sec.

Each subtest began with an example of the correct stimulus, and examples of some of the other stimuli. Following this, the correct stimulus appeared again two times, succeeded by 10 practice stimuli, 3 of which were correct. The correct stimulus then appeared one more time before the test began. Timing for the practice stimuli was the same as for the test stimuli.

The Speed of Auditory Perception Test

The auditory adaptation of the test (hereafter called the SAPT), was accomplished by means of a stereo tape. Using a stop-watch for timing, E recorded the stimuli on both channels of a Sony Stereo Tapecorder (model T230). Care was taken to control for pitch, volume and duration while saying the letters. The letters were said at the rate of one letter per 0.360 sec,[3] the same rate at which the letters appear on the screen in the SVPT. Approximately 3,500 secs of tape time was allowed to elapse between

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3. Despite many hours of practice, it was impossible to obtain the level of accuracy of timing achieved for the SVPT. Nevertheless, after many trials and errors, a surprising level of accuracy was obtained. E is confident that a very close approximation to the sought-after equivalence was achieved.

stimulus units. This corresponds approximately with the film time which elapsed during the ISI and the PI on the SVPT. As on the SVPT, examples and practice sessions preceded each subtest. Essentially, the SAPT and the SVPT were equivalent in terms of the stimuli and the timing.

Timing Device and Response Mechanism

The timing and response mechanism consisted of a Hunter Digital Counter/Timer (model 1520), a photo-electric cell, a Hunter Noise-operated Relay (model 320S), a lever-operated micro-switch and a control panel.

For the SVPT, the photo-electric cell, which was connected electrically to the START terminal of the counter, was mounted on a wooden stand and placed approximately 2 feet from, and slightly to the right of, the screen. Whenever light appeared on the screen (beginning of the PI), the counter was activated.

For the SAPT, the microphone unit of the noise-operated relay, which was also connected electrically to the START terminal of the counter, was placed on a table, 4 in from one of the stereo speakers in a smaller room adjoining the testing room. The gain control on the noise-operated relay was set at a level such that the counter would be activated by the sound of the stimuli but not by other sounds, such as static or the ticking of the

stop-watch coming through the speaker.

The response mechanism was composed of a lever-pressing device consisting of a lever-operated micro-switch mounted in a small metal box which, in turn, was mounted on an 8 in X 15 in piece of ½ in plywood. Soldered to the micro-switch lever, and projecting through a hole in the metal box was a 2 in extension on the end of which was soldered a round, flat metal disc approximately 3/4 in in diameter. The lever at its outer end had a travel distance of approximately 1 in, this distance being limited by a "kitchen-door" magnet which was secured to the plywood mounting. The magnet prevented the lever from returning to its resting position until it was lifted manually. This precaution was included so that, once stopped (say after an anticipatory response), the counter would not be reactivated during the remainder of the stimulus interval (SI). The micro-switch was connected electrically to the STOP terminal of the counter.

The control panel consisted of a switch which allowed for the selection of either the visual or auditory condition, a stop button which was connected to the STOP terminal of the counter, and a reset button which was connected to the RESET terminal of the counter.

The Testing Room

The testing was done in a trailer fully equipped for this type of research. It was insulated and temperature-controlled, and contained two rooms separated by a door. The testing room measured approximately 7 feet, 11 in wide X 11 feet, 7 in long X 6 feet, 9 in high. The walls were uniformly covered with light-stained wood panelling, the ceiling with white panels, and the floor with medium-dark indoor-outdoor carpeting. The trailer was towed to each school and parked in the schoolyard.

The testing room was arranged as follows. The projector was mounted on a small table close to the near wall. The screen was mounted on the far wall towards the left corner, high enough so that its center would be at eye-level when S was seated. A larger table was placed crossways in front of the projector table. On the left of this table were the tape recorder and one of the speakers, in the center was the control panel, and on the right of this table were the counter and the noise-operated relay control unit. S's chair was placed in the near corner to the left of the projector, approximately 10 feet from the screen. The response lever was mounted on the right arm-rest of S's chair. E's chair was placed in the near corner to the right of the projector. In this position E could easily reach the projector switch,

the tape recorder switch, and the buttons on the control panel, while at the same time he was well able to view the face of the counter, watch the screen, and observe S. A small desk-type flourescent lamp was mounted on top of the box containing the counter and noise-operated relay control unit. This lamp was the only source of light used during all the testing sessions. Its direct lighting provided sufficient illumination for E to see the equipment controls, the scoring sheet and S, while at the same time allowing for the rest of the room to remain relatively dark in comparison. The microphone for the noise-operated relay was placed (as described previously, p.19) in the small adjoining room and the door between the rooms was always closed during testing. This was done so that the sounds in the testing room (e.g., instructions, switches) would not activate the counter. A graphic illustration of this arrangement is contained in Appendix E.

Order of Presentation

Each S received both the SVPT and the SAPT. One-half of the Ss received the SVPT first and the SAPT two days later (the V-A Condition). The other Ss received the SAPT first and the SVPT two days later (the A-V Condition). Two Ss became ill after receiving the first test and did

not receive the second test until six days later. Both were older Ss and both were in the A-V Condition; one a good reader, one a poor reader.

Order was introduced into this study to control for the possible effects of practice and fatigue. This was done primarily to effect a direct comparison between auditory and visual perception. Order effect in the sense employed here (i.e., as a control variable) refers to the order in which each task was presented [i.e., (Order I - SVPT first, SAPT first); (Order II - SVPT second, SAPT second)]. In this sense, Order is a within-S variable. Order may be construed in another sense [i.e., (Condition I - SVPT first, SAPT second); (Condition II - SAPT first, SVPT second)]. In this sense Order is a between-S variable. Both concepts are included in the analysis of the data. In order to determine the effects of Order on the Modality factor, diagonal comparisons were necessary.

Testing

All testing was done during school hours. Each S was brought from his classroom to the trailer by E. When S entered the testing room he was asked to sit in the chair. E then sat down and gave the following instructions for the first test. " We are going to do some short tests which involve looking at (or listening to) letters and

groups of letters, and pressing a lever. There are six different tests. In each test you will see (or hear) many different letters or groups of letters, but only one letter or one group will be the correct one. Before each test begins I will show (or tell) you the correct one. I will also show (or tell) you examples of some of the other letters or groups which are not correct. After this you will see (or hear) the correct letter or group two more times, and then you can practice for awhile. What I want you to do is to press this lever (demonstrate) as quickly as you can, as soon as you see (or hear) the correct letter or correct group, but you are not to press it for any other letter or group. Whenever you press the lever, you must pull it back up so you will be ready for the next letter or group." S was then allowed to press the lever and pull it back up several times to make certain he was able to do this with facility. No S had difficulty doing this. The detailed instructions were then given and the testing began. These instructions are contained in Appendix F. If S had difficulty during the practice session and was not responding to the correct stimulus, E pointed this out and told him when to respond. Once the subtest began, no other instructions were given except that E said "ready" before each stimulus appeared or was heard. In the S/PT an extra

preparatory signal was provided by the 0.730 sec of light on the screen immediately preceding the appearance of the stimulus. This was included because pilot work had shown that children occasionally had a tendency to momentarily take their eyes off the screen even after the "ready" signal was given. Total test time was approximately 20 to 25 min. When the test was completed, S was instructed that he would be asked to return in two days to do something else. He was asked not to discuss the test with classmates, and particularly not to reveal the actual stimuli. When S returned for the second test, instructions were modified as follows. "You remember that in the last session you were looking at (or listening to) letters and groups of letters and pressing this lever. This time you are going to listen to (or look at) letters and groups of letters and press the lever." He was not told that he would be seeing (or hearing) the same stimuli.

As explained previously, (p.19), when the light appeared on the screen, or when the initial sound of the stimulus was heard through the speaker, the counter started. Whenever S responded, the counter stopped and E recorded the elapsed time for each correct stimulus on a recording sheet. If S responded to an incorrect stimulus or did not respond to a correct one, a zero was recorded, signifying an error. Once S responded and the appropriate

recording was made, E then pressed the reset button on the control panel, clearing the counter to 0.000 for the next stimulus. For the SVPT, the counter was permitted to run until a reading of 5.000 sec was reached and, if S had not responded by that time, E pressed the stop and reset buttons on the control panel while saying "ready" for the next stimulus. For the SAPT , the counter was permitted to run until a reading of 4.000 sec was reached. For the SVPT, a constant 0.730 sec (the elapsed time for the PI) was subtracted from each score. These time intervals applied to the four-letter stimuli. Since stimulus time for the single-letter stimuli differed by 1.08 sec from the stimulus time for the four-letter stimuli, the counter was permitted to run until readings of 4.000 sec (SVPT) and 3.000 sec (SAPT) were reached.

The individual stimuli (i.e., s, b or m; fsbm, narp; spot; nest) do not lend themselves to an easy description in terms of a particular factor. These stimuli would appear to differ in several ways. The first two may differ in complexity, since S must keep in mind two letters in the case of b or m and only one letter in the case of s. The four-letter stimuli may or may not differ in complexity. However, they would certainly seem to differ in several other respects. First, fsbm and narp are not words and, therefore, are less familiar and have less meaning

than spot and nest. Additionally, narp is pronouncable, whereas fsbm is not. Consequently, although these six stimuli are treated as various levels of a particular factor, it is difficult to assign a specific name to this factor. Furthermore, it was not possible to subject it to any quantitative scaling. However, in order to facilitate explanation of the various analyses, this variable will be designated as "complexity."

CHAPTER III

RESULTS

The means and standard deviations for Age, WISC prorated PIQ, and MAT Word Knowledge and Reading subtest scores for each of the four groups are presented in Table 1. Comparisons of the means for the control variables of Age and WISC prorated PIQ at each grade level revealed no significant differences.

Table 1

Means (M) and Standard Deviations (s) for Age, WISC Prorated PIQ, and MAT Word Knowledge and Reading Subtest Scores for the Four Experimental Groups

Groups	n	Age in Months	Prorated PIQ	MAT Word Know. % ile	MAT Reading % ile
Younger Good	16	M 96.88 s 6.31	M 103.31 s 7.04	M 84.81 s 7.10	M 76.44 s 6.87
Younger Poor	16	M 93.87 s 4.64	M 101.56 s 7.17	M 29.31 s 14.23	M 19.25 s 8.68
Older Good	16	M 140.63 s 6.07	M 102.75 s 7.81	M 77.31 s 11.16	M 73.94 s 5.07
Older Poor	16	M 144.19 s 5.93	M 102.81 s 8.20	M 35.88 s 10.72	M 16.67 s 8.97

An explanation of the two concepts of the "Order"

Latency of Response

As is frequently the case with latency data, the distributions were somewhat skewed. However, since the shapes of the curves were all very similar, and since the variances were fairly homogeneous, the data were analysed by means of analysis of variance.

Since latency of response was measured from the onset of the stimulus, and the amount of time which the single-letter stimuli were present differed by 1.08 sec from the amount of time the four-letter stimuli were present, the data were analysed separately for the single-letter stimuli and the four-letter stimuli.

Single-letter Stimuli

The means and standard deviations for latency of response as a function of Age, Reading Level, Order, Modality, and Complexity for single-letter stimuli are presented in Table 2. These data were analysed by means of a 2(Age) X 2(Reading Level) X 2(Order) X 2(Modality) X 2(Complexity) analysis of variance. The results of this analysis are summarized in Table 6, in Appendix G.

The main effect of Age was significant (F=36.58,

Table 2

Means (M) and Standard Deviations (s) for Latency of Response as a Function of Age, Reading Level, Order, Modality, and Complexity for Single-letter Stimuli

				Visual			Auditory	
				s	b or m		s	b or m
Younger	Good	Order I	M	0.72	0.79	M	0.67	0.80
			s	0.13	0.10	s	0.09	0.16
		Order II	M	0.73	0.87	M	0.74	0.83
			s	0.06	0.13	s	0.09	0.19
	Poor	Order I	M	0.71	0.81	M	0.74	0.88
			s	0.10	0.11	s	0.11	0.15
		Order II	M	0.73	0.82	M	0.73	0.79
			s	0.11	0.14	s	0.16	0.15
Older	Good	Order I	M	0.61	0.66	M	0.52	0.60
			s	0.07	0.08	s	0.16	0.16
		Order II	M	0.65	0.69	M	0.63	0.75
			s	0.10	0.10	s	0.19	0.18
	Poor	Order I	M	0.61	0.61	M	0.55	0.63
			s	0.09	0.07	s	0.09	0.17
		Order II	M	0.65	0.69	M	0.49	0.60
			s	0.07	0.07	s	0.12	0.11

The main effect of Age was significant (F=36.58, df=1/56, p <.001), indicating that the older Ss performed much faster than the younger Ss. The analysis also revealed a significant main effect of Complexity (F=55.63, df=1/56, p <.001), a significant Modality X Complexity interaction (F=4.20, df=1/56, p<.05), and a significant Reading Level X Order X Modality interaction (F=4.09, df=1/56, p <.05). As can be seen in Figure 1, the Modality X Complexity interaction can be explained by the fact that, whereas performance on subtest 1 was faster than performance on subtest 2 on both the SVPT (F=21.40, df=1/112, p <.001) and the SAPT (F=51.09, df=1/112, p <.001), performance on the SAPT was faster than that on the SVPT only on subtest 1 (F=5.05, df=1/112, p <.05). These results are summarized in Table 7, in Appendix G.

In order to examine the Reading Level X Order X Modality interaction, the simple Order X Modality interaction effects were computed at each Reading Level. A summary of this analysis is presented in Table 8, in Appendix G. As explained on page 23, this analysis was accomplished by means of diagonal comparisons (i.e. visual first vs. auditory first; visual second vs. auditory second).[3] The arrows in Table 3 indicate these

3. Analysis of all subsequent interactions in which Order and Modality were involved were accomplished in this same manner.

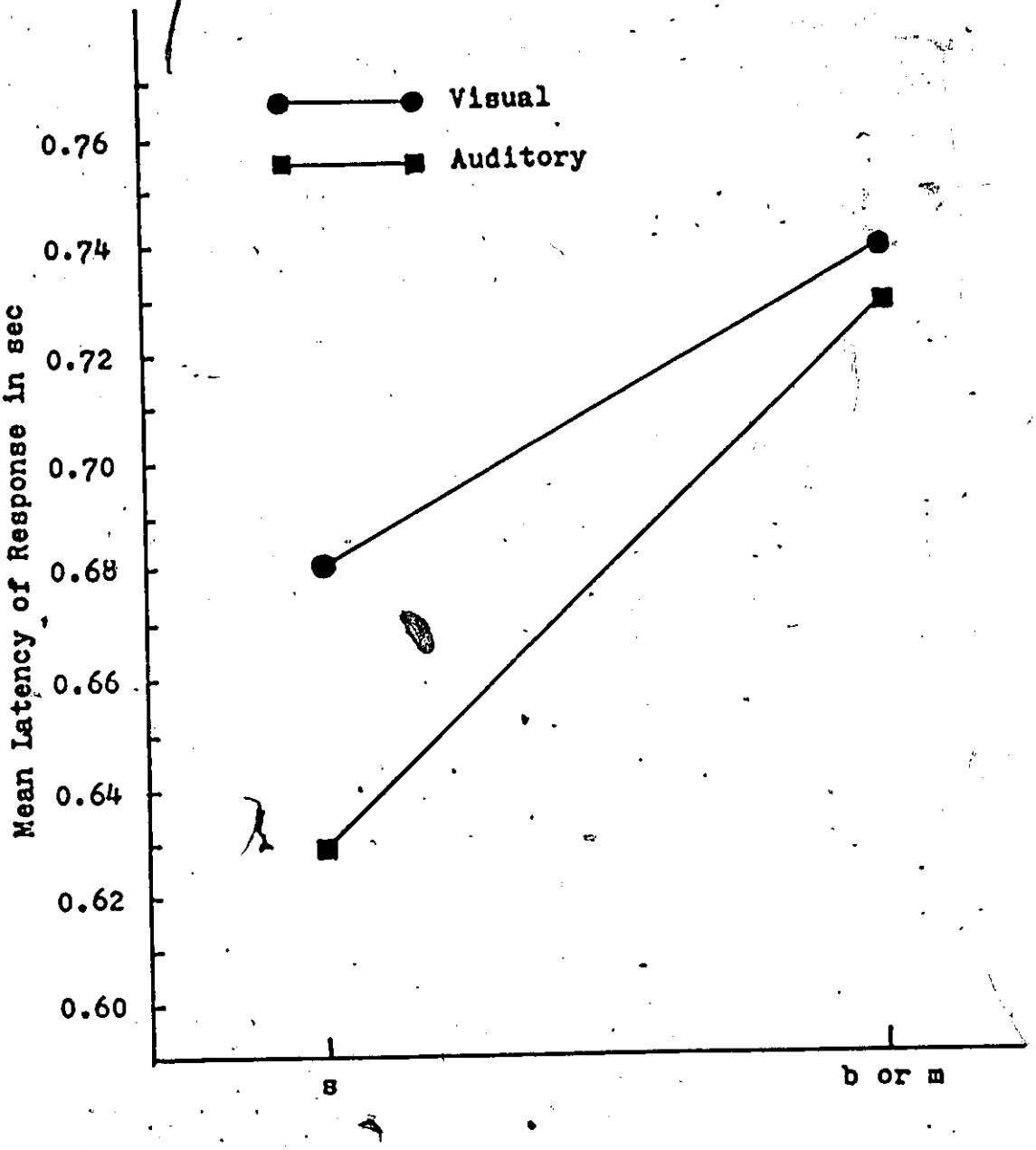


Figure 1. Mean latency of response on the SVPT and SAPT for single-letter stimuli (subtests 1 & 2).

comparisons. The results of this analysis revealed an

Table 3

Means of Latency Scores of Good and Poor Readers on the SVPT and SAPT for the V-A Condition and A-V Condition with Arrows Indicating Diagonal Comparisons for Order Effect

	Good		Poor	
	Visual	Auditory	Visual	Auditory
V-A Condition (visual first-auditory second)	1.39	1.29	1.37	1.40
A-V Condition (auditory first-visual second)	1.47	1.48	1.44	1.30

Order X Modality interaction only for the good readers (F=5.03, df=1/112, $p < .05$). This interaction was further analysed by computing the simple main effect of Modality for each Order. This analysis revealed a simple main effect of Modality only for Order I (F=5.35, df=1/56, $p < .05$). As may be seen in Figure 2, this indicated that the good readers performed faster on the SAPT than they did on the SVPT only when each task was given second.

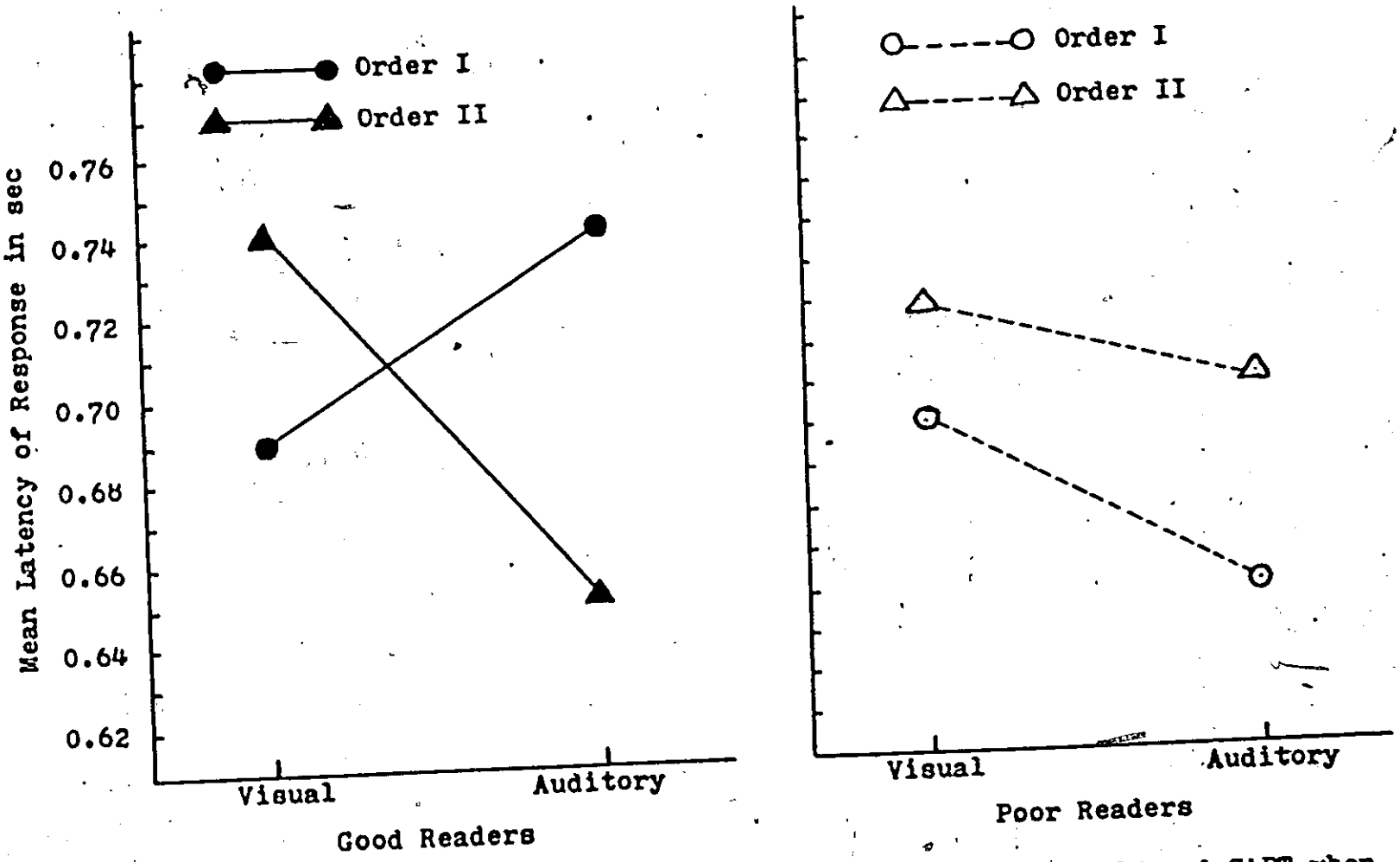


Figure 2. Mean latency of response on Subtests 1 and 2 on the SVPT and SAPT when each task was presented first (Order I) and second (Order II).

Four-letter Stimuli

The means and standard deviations for latency of response as a function of Age, Reading Level, Order, Modality and Complexity for four-letter stimuli are presented in Table 4. The latency data for subtests 3, 4, 5, and 6 were also analysed by means of a 2(Age) X 2(Reading Level) X 2(Order) X 2(Modality) X 4(Complexity) analysis of variance. The results of this analysis are summarized in Table 9, in Appendix G. The main effects for Age (F=60.31, df=1/56, $p < .001$), Order (F=7.26, df=1/56, $p < .01$), Modality (F=82.46, df=1/56, $p < .001$), and Complexity (F=5.98, df=3/168, $p < .05$) were significant. The analysis also revealed a significant Order X Modality interaction (F=8.40, df=1/56, $p < .01$), a significant Modality X Complexity interaction (F=3.23, df=3/168, $p < .05$), and a significant Age X Reading Level X Modality X Complexity interaction (F=3.46, df=3/168, $p < .05$).

Analysis of the simple main effects of the Order X Modality interaction indicated that, although performance on the SAPT was significantly faster than performance on the SVPT whether the tasks were given first (F=17.09, df=1/56, $p < .05$) or second (F=90.49, df=1/56, $p < .001$), the main effect of Order was significant only for the SAPT (F=14.60, df=1/112, $p < .05$). This analysis is

Table 4

Means (M) and Standard Deviations (s) for Latency of Response as a Function of Age, Reading Level, Order, Modality, and Complexity (Four-letter Stimuli)

				Visual				Auditory			
				fsbm	narp	spot	nest	fsbm	narp	spot	nest
Younger	Good	Order I	M	2.02	1.97	1.96	2.10	1.88	1.70	1.64	1.71
			s	0.34	0.31	0.14	0.25	0.32	0.34	0.27	0.24
		Order II	M	2.10	2.07	2.06	2.16	1.94	1.89	1.67	1.84
			s	0.21	0.11	0.23	0.18	0.26	0.25	0.22	0.18
	Poor	Order I	M	2.08	2.17	1.98	2.10	1.86	1.80	1.82	1.83
			s	0.25	0.22	0.16	0.21	0.15	0.31	0.34	0.27
		Order II	M	2.11	2.11	2.04	2.14	1.97	2.08	2.03	2.06
			s	0.14	0.09	0.13	0.10	0.31	0.26	0.49	0.50
Older	Good	Order I	M	1.84	1.80	1.73	1.75	1.36	1.33	1.32	1.33
			s	0.07	0.06	0.17	0.16	0.21	0.18	0.19	0.23
		Order II	M	1.85	1.63	1.73	1.74	1.69	1.67	1.46	1.44
			s	0.28	0.23	0.23	0.19	0.26	0.29	0.28	0.33
	Poor	Order I	M	1.72	1.67	1.72	1.73	1.53	1.32	1.35	1.30
			s	0.16	0.20	0.17	0.18	0.20	0.18	0.24	0.19
		Order II	M	1.82	1.77	1.79	1.81	1.72	1.66	1.58	1.59
			s	0.20	0.20	0.25	0.22	0.23	0.18	0.21	0.27

summarized in Table 10, in Appendix G. The Order effect is clearly illustrated in Figure 3, where it can be seen that those Ss who received the SAPT second performed faster than those who received it first, whereas, it made no difference whether the SVPT was performed first or second.

In order to examine the third-order interaction, additional 2(Reading Level) X 2(Modality) X 2(Complexity) analyses of variance were computed for each age-level separately.

Younger Ss

A summary of the analysis for the younger Ss is contained in Table 11, in Appendix G. The results of this analysis revealed only a significant main effect for Modality (F=37.31, df=1/30, $p < .001$), indicating that, for the younger Ss, performance on the SAPT was faster than that on the SVPT regardless of Reading Level or Complexity.

Older Ss

A summary of the analysis for the older Ss is contained in Table 12, in Appendix G. This analysis revealed a significant main effect for Modality (F=59.22, df=1/30, $p < .001$) and Complexity (F=9.26, df=3/90, $p < .01$). There was also a significant Modality X Complexity interaction (F=4.23, df=3/90, $p < .01$). The simple effects of this

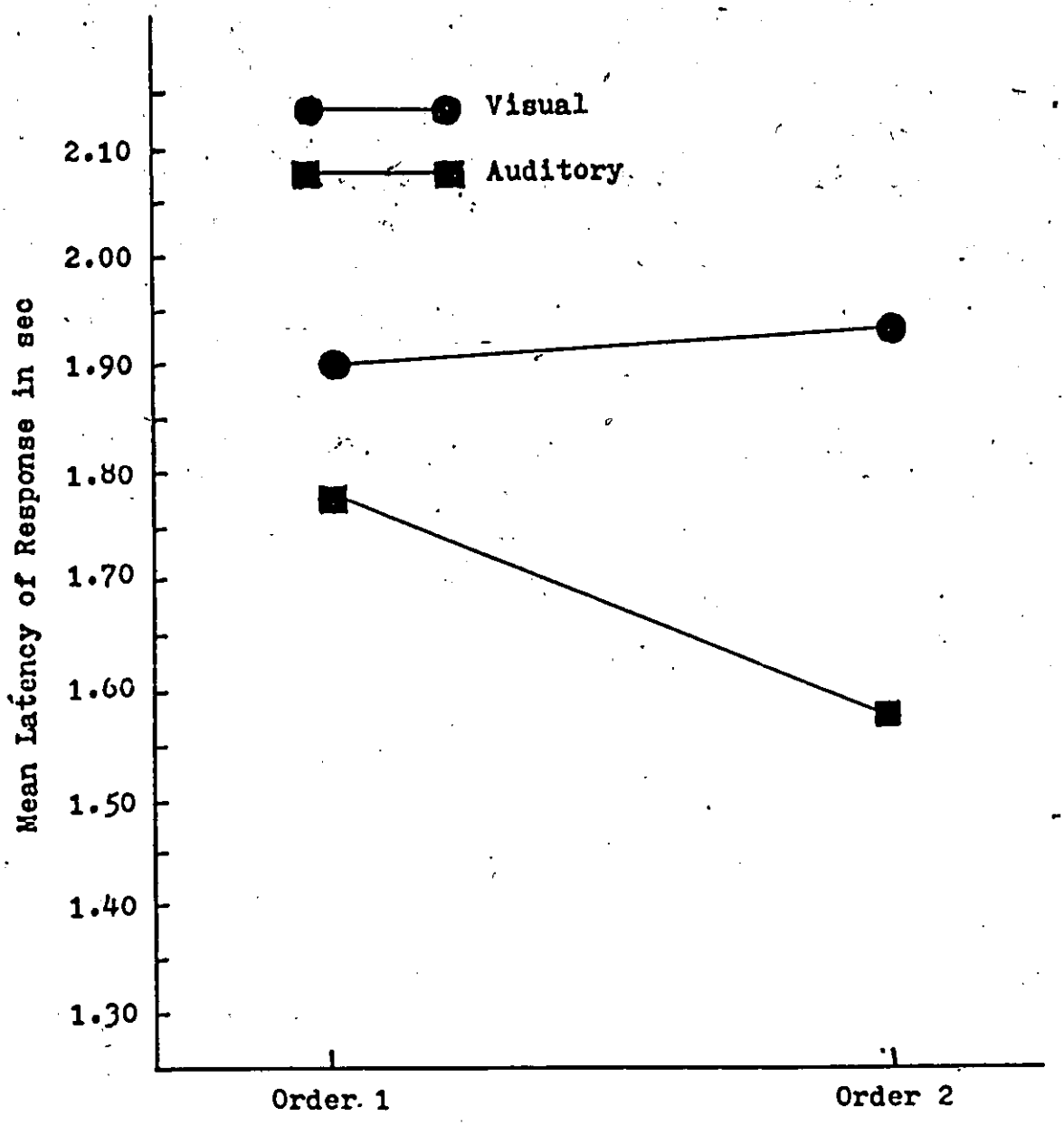


Figure 3. Mean latency of response to four-letter stimuli (subtests 3, 4, 5 & 6) for Order I (Visual first vs. Auditory first) and Order II (Visual second vs. Auditory second)

interaction were computed and are summarized in Table 13, in Appendix G. This analysis revealed that performance on the SAPT was significantly faster than performance on the SVPT for all four subtests, subtest 3 (F=21.11, df=1.22, $p < .001$), subtest 4 (F=23.16, df=1/224, $p < .001$), subtest 5 (F=39.59, df=1/224, $p < .001$), and subtest 6 (F=47.32, df=1/224, $p < .001$). However, the interaction can be explained by the fact that there was a significant simple main effect of Complexity only for the SAPT (F=6.29, df=3/336, $p < .01$). A Newman-Keuls test of the difference between the means for the SAPT at all four levels of Complexity was computed. The results, which are summarized in Table 14, in Appendix G, demonstrated significant differences ($p < .05$) between subtests 3 and 6, subtests 3 and 5, and subtests 4 and 6. These relationships, illustrated in Figure 4, indicate that, for the SAPT, performance was faster for pronounceable words (spot and nest) than for the unpronounceable unit (fsbm). It also indicated that performance was faster for the pronounceable word (nest) than for the pronounceable nonsense unit (narp).

Errors

The error data resulted in within-cell distributions which departed, to some degree, from normality. Furthermore, the variance within each of the four reading groups

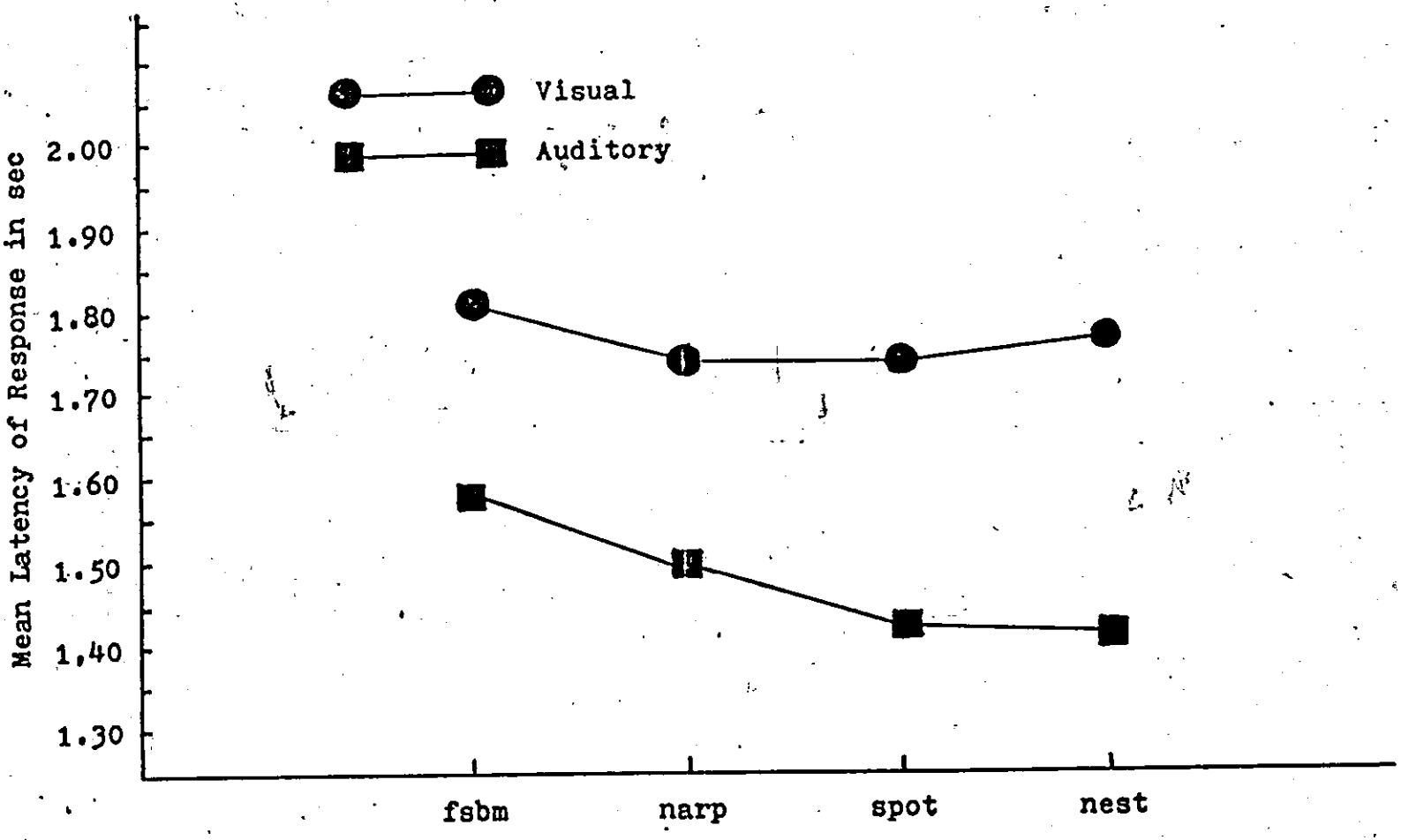


Figure 4. Mean latency of response of older Ss on the SVPT and SAPT for subtests 3, 4, 5 & 6.

was not homogeneous. For these reasons, each error score was transformed using the formula $\sqrt{X+1}$, as suggested by Winer (1962, p. 221). The desired homogeneity of variance was obtained, but the shapes of the distributions were not altered significantly; i.e., they were still non-normal. However, because the distributions were all very similar, and since the F ratio is reported to be relatively insensitive to moderate departures from normality (Box, 1953), the error data were compared by means of analysis of variance. The means and standard deviations for the transformed error scores as a function of Age, Reading Level, Order, Modality, and Complexity are presented in Table 5.

The data were analysed by means of a 2(Age) X 2(Reading Level) X 2(Order) X 2(Modality) X 6(Complexity) analysis of variance. The results of this analysis are summarized in Table 15, in Appendix G. The main effects of Age ($F= 63.31$, $df=1/56$, $p<.001$), Reading Level ($F=18.46$, $df=1/56$, $p<.001$), Order ($F=10.54$, $df=1/56$, $p<.01$), and Complexity ($F=4.49$, $df=5/280$, $p<.001$) were significant. The analysis also revealed a significant Age X Reading Level interaction ($F=16.04$, $df=1/56$, $p<.001$), a significant Order X Modality interaction ($F=5.95$, $df=1/56$, $p<.05$), a significant Age X Complexity interaction ($F=2.75$, $df=5/280$, $p<.05$), a significant Reading Level X Complexity interaction

Table 5

Means (M) and Standard Deviations (s) for Transformed Error Scores as a Function of Age, Reading Level, Order, Modality and Complexity

				Visual							Auditory					
				s	b or m	fsbm	narp	spot	nest		s	b or m	fsbm	narp	spot	nest
Younger	Good	Order I	M	1.10	1.42	1.22	1.09	1.21	1.05	M	1.05	1.05	1.15	1.05	1.23	1.14
			s	0.18	0.31	0.38	0.24	0.41	0.14	s	0.14	0.14	0.20	0.14	0.32	0.26
		Order II	M	1.15	1.30	1.05	1.05	1.25	1.12	M	1.10	1.15	1.34	1.35	1.23	1.25
			s	0.20	0.25	0.14	0.14	0.26	0.18	s	0.18	0.20	0.29	0.42	0.32	0.26
	Poor	Order I	M	1.19	1.25	1.32	1.35	1.46	1.23	M	1.00	1.30	1.45	1.21	1.15	1.46
			s	0.27	0.26	0.36	0.23	0.49	0.32	s	0.00	0.25	0.38	0.21	0.20	0.49
		Order II	M	1.05	1.45	1.60	1.23	1.33	1.14	M	1.19	1.28	1.73	1.48	1.83	1.86
			s	0.14	0.37	0.56	0.34	0.32	0.26	s	0.27	0.33	0.50	0.41	0.65	0.55
Older	Good	Order I	M	1.10	1.14	1.05	1.00	1.05	1.09	M	1.00	1.19	1.05	1.13	1.05	1.00
			s	0.18	0.26	0.14	0.00	0.14	0.24	s	0.00	0.27	0.14	0.33	0.14	0.00
		Order II	M	1.10	1.19	1.05	1.15	1.10	1.21	M	1.10	1.10	1.05	1.00	1.00	1.05
			s	0.18	0.27	0.14	0.20	0.18	0.21	s	0.18	0.18	0.14	0.00	0.00	0.14
	Poor	Order I	M	1.05	1.29	1.05	1.00	1.00	1.09	M	1.00	1.10	1.05	1.00	1.00	1.00
			s	0.14	0.31	0.14	0.00	0.00	0.24	s	0.00	0.18	0.14	0.00	0.00	0.00
		Order II	M	1.10	1.14	1.09	1.05	1.00	1.05	M	1.00	1.19	1.62	1.05	1.10	1.00
			s	0.18	0.26	0.24	0.14	0.00	0.14	s	0.00	0.27	0.70	0.14	0.18	0.00

(F=2.49, df=5/280, $p < .05$), a significant Modality X Complexity interaction (F=5.27, df=5/280, $p < .001$), a significant Age X Modality X Complexity interaction (F=4.41, df=5/280, $p < .001$), a significant Age X Reading Level X Modality X Complexity interaction (F=2.57, df=5/280, $p < .05$), and a significant Age X Order X Modality X Complexity interaction (F=2.81, df=5/280, $p < .05$). Finally, there was a significant Age X Reading Level X Order X Modality X Complexity interaction (F=4.19, df=5/280, $p < .001$).

In order to examine the the fourth-order interaction, additional 2(Reading Level) X 2(Order) X 2(Modality) X 6(Complexity) analyses of variance were calculated at each age-level separately.

Younger Ss

A summary of the analysis for the younger Ss is presented in Table 16, in Appendix G. The results of this analysis revealed significant main effects of Reading Level (F=22.44, df=1/28, $p < .001$), Order (F=6.29, df=1/28, $p < .05$) and Complexity (F=4.11, df=5/140, $p < .01$). This analysis also revealed a significant Order X Modality interaction (F=5.98, df=1/28, $p < .05$) and a significant Modality X Complexity interaction (F=4.92, df=5/140, $p < .01$). Finally, there was a significant Reading Level X Order X Modality X Complexity interaction (F=3.83, df=5/140, $p < .01$).

To examine this third-order interaction for the younger Ss, additional 2(Reading Level) X 2(Modality) X 6 (Complexity) analyses of variance were computed for Order I and Order II separately. A summary of the analysis for Order I is presented in Table 17, in Appendix G. This analysis revealed that the main effects of Reading Level (F=19.42, df=1/21, $p < .001$), Modality (F=7.99, df=1/21, $p < .01$), and Complexity (F=2.52, df=5/140, $p < .05$) were significant. There was also a significant Reading Level X Modality interaction (F=9.30, df=1/21, $p < .01$) and a significant Modality X Complexity interaction (F=3.85, df=5/140 $p < .05$).

In order to examine the Reading Level X Modality interaction, the simple main effects were computed. The results of this analysis which are summarized in Table 18, in Appendix G, revealed that the main effect of Reading Level was significant for both the SVPT (F=5.18, df=1/14, $p < .05$) and the SAPT (F=28.12, df=1/14, $p < .001$); but that the main effect of Modality was significant only for the poor readers (F=15.91, df=1/14, $p < .01$). As can be seen in Figure 5, this indicated that the poor readers made more errors than the good readers on both tasks, and also that the poor readers made more errors on the SAPT than on the SVPT.

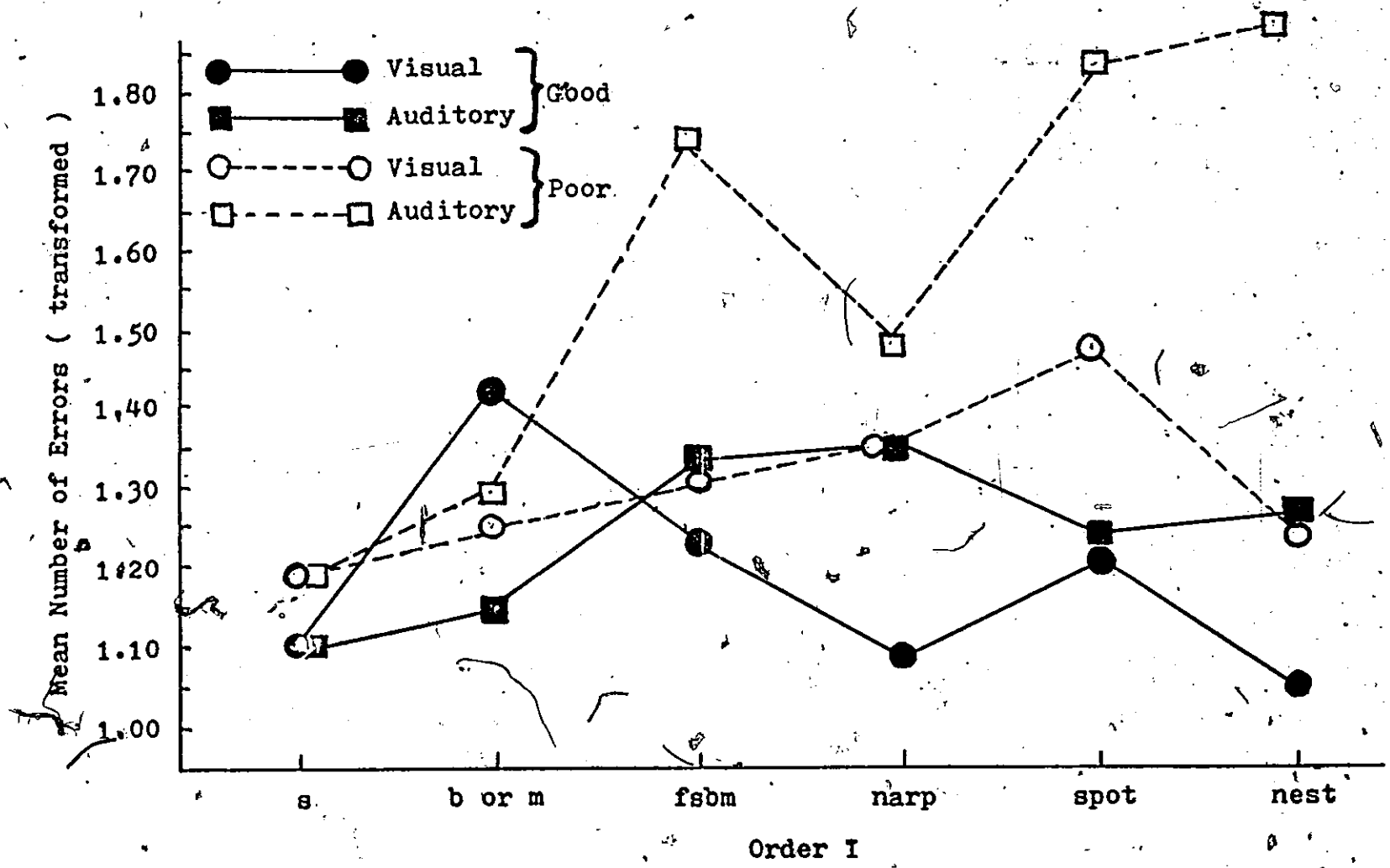


Figure 5. Mean number of errors of younger Ss on the SVPT and SAPT for Order I.

The simple main effects of the Modality X Complexity interaction were computed and are summarized in Table 19, in Appendix G. This analysis revealed that the main effect of Modality was significant only for subtest 3 (F=5.29, df=1/84, p <.05), subtest 5 (F=4.04, df=1/84, p <.05), and subtest 6 (F=12.72, df=1/84, p <.01), and that the main effect of Complexity was significant only for the SAPT (F=7.72, df=5/140, p <.001). These relationships are illustrated in Figure 6. A Newman-Keuls test of the difference between the means for the SAPT at all six levels of Complexity was computed. The results which are summarized in Table 20, in Appendix G, revealed that fewer errors were made on subtests 1 and 2 than on subtests 3, 4, 5, and 6 (p <.05).

A summary of the Reading Level X Modality X Complexity analysis for Order II is presented in Table 21, in Appendix G. This analysis revealed significant main effects of Reading Level (F=4.98, df=1/21, p <.05) and Complexity (F=2.31, df=5/140, p <.05) and a significant Reading Level X Complexity interaction (F=3.07, df=5/140, p <.05).

In order to examine this interaction the simple main effect of Reading Level at each level of Complexity was computed. The results, summarized in Table 22, in Appendix G, revealed that Reading Level was significant only

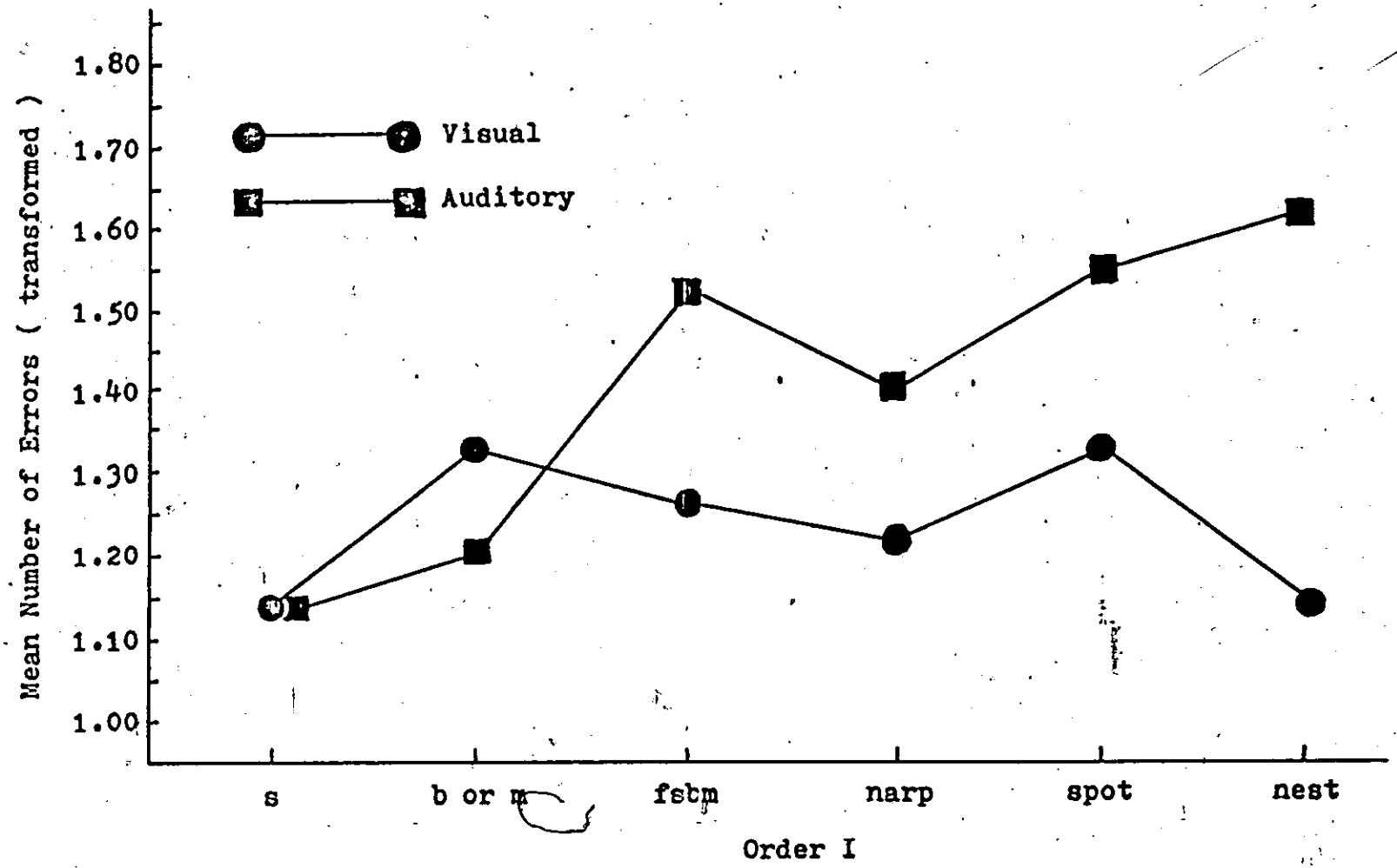


Figure 6. Mean number of errors of younger Ss on the SVPT and SAPT for Order I (Scores of Good and Poor Readers Combined).

for subtest 2 (F=4.39, df=1/84, $p < .05$) and subtest 3 (F=7.18, df=1/84, $p < .05$). As may be seen in Figure 7, this indicated that the poor readers made more errors than the good readers on subtests 2 and 3.

Older Ss

A summary of the Reading Level X Order X Modality X Complexity analysis of variance for the older Ss is presented in Table 23, in Appendix G. This analysis resulted in significant main effects for Order (F=4.74, df=1/28, $p < .05$) and Complexity (F=3.11, df=5/140, $p < .05$). Also revealed were a significant Modality X Complexity interaction (F=3.75, df=5/140, $p < .01$) and a significant Reading Level X Order X Modality interaction (F=4.88, df=1/28, $p < .05$).

The Modality X Complexity interaction can be explained by the fact that significantly fewer errors were made on the SVPT for subtest 3 (F=8.06, df=1/168, $p < .01$), significantly fewer errors were made on the SAPT for subtest 6 (F=6.27, df=1/168, $p < .05$), and there were no significant differences on the other four subtests. This is illustrated in Figure 8. A summary of the analysis is contained in Table 24, in Appendix G.

In order to examine the Reading Level X Order X Modality interaction, the simple Order X Modality interaction

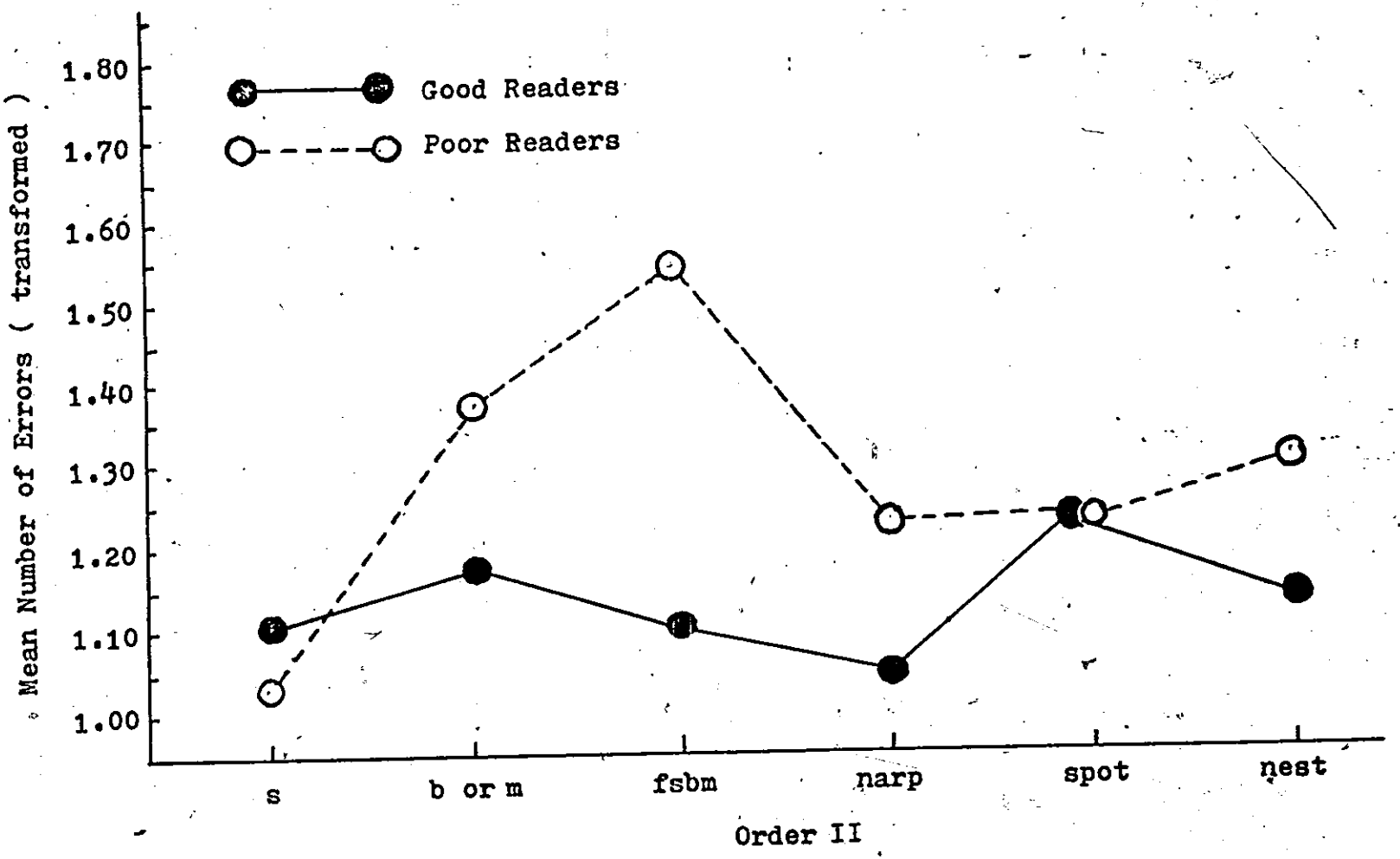


Figure 7. Mean number of errors of younger Ss on the SVPT and SAPT (combined) for Order II.

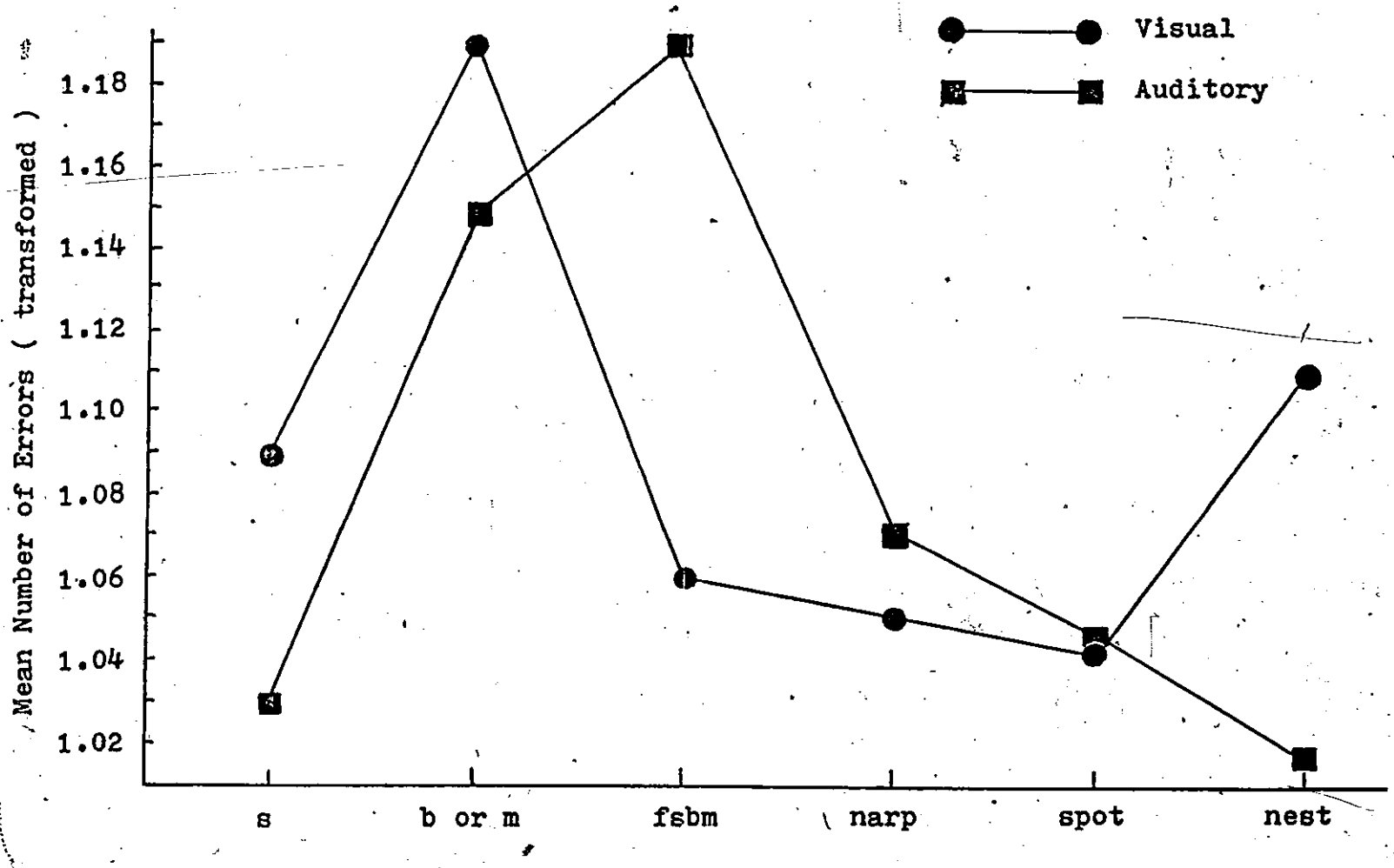


Figure 8. Mean number of errors of older Ss on the SVPT and SAPT.

effects for each Reading Level was computed. This analysis, which is summarized in Table 25, in Appendix G, revealed a significant Order X Modality interaction only for the poor readers. The simple main effects of Order for each Modality were computed and are summarized in Table 26, in Appendix G. This analysis revealed a significant Order effect only for the SAPT ($F = 5.32$, $df = 1/28$, $p < .05$). As may be seen in Figure 9, this indicated that the poor readers made significantly more errors when the SAPT was presented first than when it was presented second, but it made no difference whether the SVPT was presented first or second.

Summary of Results Relevant to Hypotheses

Visual versus Auditory Perception

Hypothesis Ia stated that, for younger children, auditory perception would be faster and more accurate than visual perception for subtests 5 and 6 (spot and nest). This hypothesis was supported by the latency data, but not by the error data . Latency of response was consistently shorter on the SAPT than on the SVPT for all four-letter stimuli. However, the opposite relationship occurred with regard to errors, i.e., fewer errors were made on the SVPT than on the SAPT on three of the four-letter stimuli, i.e., subtests 4, 5, and 6. But, this

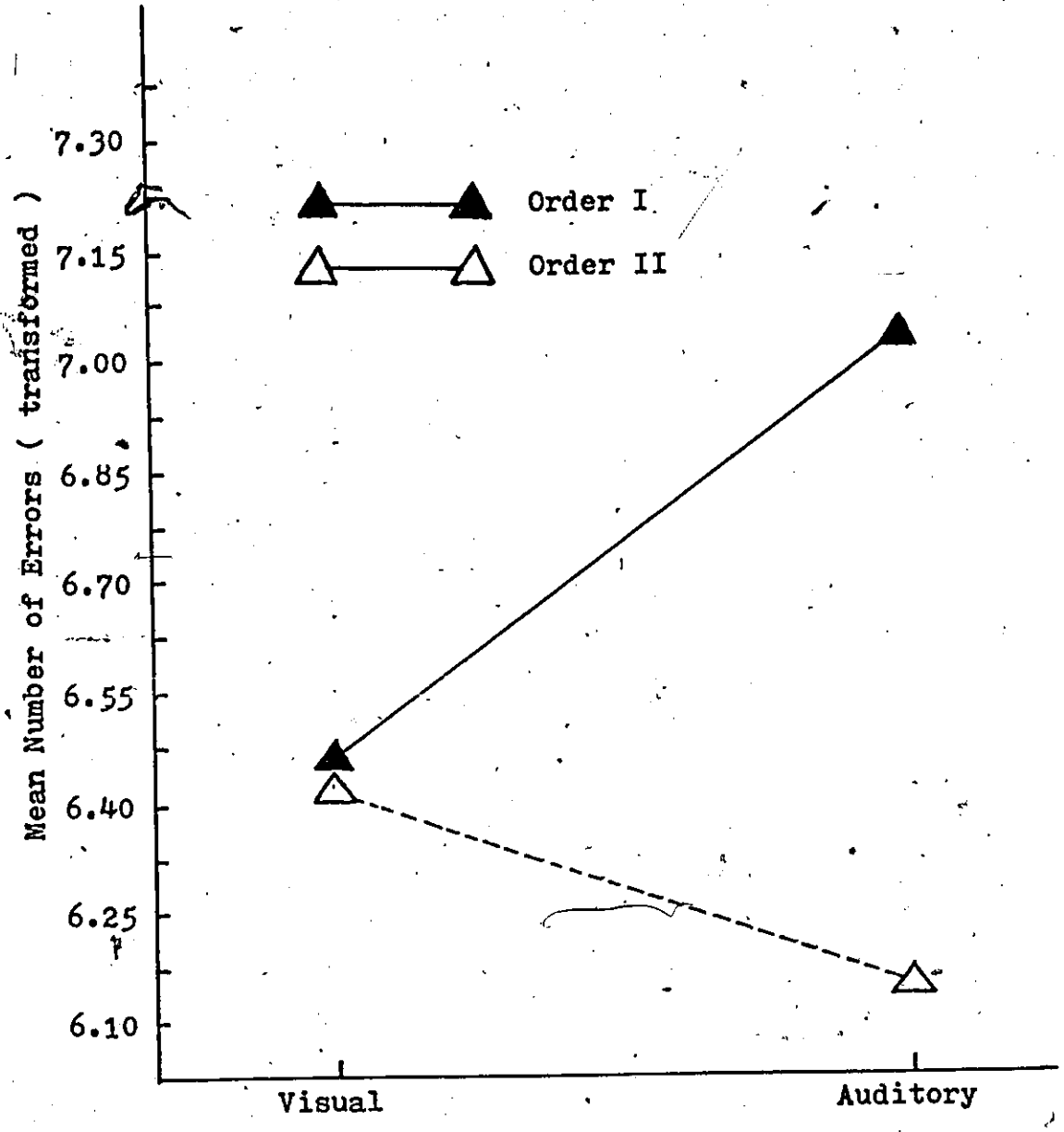


Figure 9 . Mean number of errors of older poor readers on the SVPT and SAPT for Order I (Visual first vs. Auditory first) and Order (Visual second vs. Auditory second).

usually occurred only when each task was given first. This hypothesis also stated that there would be no differences in the older Ss. However, older Ss performed faster on the SAPT than on the SVPT on these two subtests and also made significantly fewer errors on the SAPT than on the SVPT on subtest 6.

Hypothesis Ib stated that visual perception would be superior to auditory perception on subtests 3 and 4 (fsbm and narp) for all Ss. On the latency of response measure, this hypothesis was not supported, since performance was faster on the SAPT than on the SVPT for all of the four-letter subtests. However, the error data provided at least some support for this hypothesis in that the younger poor readers made more errors on the SAPT than on the SVPT on subtests 3 and 4, but this occurred only when each task was given second. Additionally, the older Ss made significantly more errors on the SAPT than on the SVPT on subtest 3.

Hypothesis Ic stated that there would be no differences in visual and auditory perception of single-letter stimuli (subtests 1 and 2). This hypothesis received partial support in that there were no differences in the error scores on subtests 1 or 2. In addition there was no difference in latency of response on subtest 2. However, latency of response was shorter for the SAPT than for the

SVPT on subtest 1.

Hypothesis Id, which stated that the older Ss would perform faster and more accurately on both the visual and auditory tasks, received complete support. On the latency measure, the older Ss always performed faster than the younger Ss. Likewise, older Ss always made fewer errors than did younger Ss.

Good Readers Versus Poor Readers

Hypothesis IIa stated that, for four-letter stimuli, the younger good readers would perform faster and more accurately than the younger poor readers on both the visual and auditory tasks, particularly on the auditory task. The results for the error scores supported this hypothesis particularly when each task was presented first. However, there were no significant differences in the latency of response data.

Hypothesis IIb stated that (1) the older poor readers would not differ from the older good readers on the visual task, but that (2) the older poor readers would be slower and less accurate than the older good readers on the auditory task. Part (1) of this hypothesis was fully supported. In general, there was little support for part (2), except in the case of subtest 3 (fsbm). On the SAPT, the poor readers made significantly more errors on this subtest than did the good readers when the SAPT was given first.

CHAPTER IV

DISCUSSION

One of the major purposes of this study was to determine whether or not there was a difference in children's ability to perceive letter sequences through the auditory as compared to the visual modality. The results provided unequivocal evidence that children are able to process letter sequences faster auditorally than visually, regardless of age, reading level, and order of presentation, and regardless of the complexity, familiarity or meaningfulness of the stimuli. However, in general (except in the case of younger children who read poorly), they do not appear to demonstrate any consistent visual-auditory differences in the accuracy of their perceptions.

These results are not consistent with the results of studies which employed recall or paired-associate tasks. Lockhard and Sidowski (1961) and Cooper and Gaeth (1967), among others, have shown that the visual modality was superior to the auditory for non-verbal stimuli. Rohlman (1906), Budoff and Quinlan (1964), and Durrell (1969), among others, have shown that, on similar tasks involving verbal material, the auditory modality was superior to the visual, but only in younger children.

Since simple auditory reaction is faster than simple visual reaction time (e.g., Gaudner & Rourke, 1972; Goldstone, 1966; Rourke & Gaudner, 1972),

it might be argued that the superiority of the auditory modality in the present investigation was due to the difference in reaction time. Admittedly, there is an element of reaction time in the task employed, and this may have contributed, to some extent, to the modality difference obtained. However, a closer examination of the results does not support a reaction-time interpretation. If simple reaction time were the critical factor, the obtained differences should have been as great or even greater for single-letter stimuli than for four-letter sequences. However, the opposite relationship was found. The greatest differences were obtained for four-letter sequences where the results were all highly significant (i.e., well beyond the .001 level). And, in fact, while auditory sequencing was faster than visual for subtest 1 (s), no differences were obtained on subtest 2 (b or m). Consequently, another explanation would seem more probable.

In the previous studies cited, the requirements were relatively simple and involved little more than a memory component. The task used in the present study would seem to be somewhat more complex. Together with remembering the correct letter sequence, S was required to recognize it quickly, discriminate it from other highly similar sequences, and then respond. It would appear that the

auditory modality is more efficient for this type of processing whether the stimuli are verbal or non-verbal and whether the children are young or old.

Order of presentation, which was introduced into this study only as a control variable, resulted in a very interesting (serendipitous) finding pertaining to the superiority of the auditory modality. When the auditory task followed the visual task there was a very significant decrease in latency of response. However, when the visual task followed the auditory task there was no such improvement. In fact, there was a slight, though non-significant, increase in latency, i.e., those Ss who received the visual task second performed more slowly than did those who received it first. In other words, there was a significant visual to auditory facilitation, whereas there was no auditory to visual facilitation. If anything, a slight decrement occurred in the case of the latter order. This finding is not surprising if viewed in the context of the visual-information-processing model suggested by Sperling (1969). According to Sperling , when S is processing a visual-symbolic stimulus (e.g., a letter or letters), the stimulus is first stored in visual information storage (VIS), then scanned and rehearsed subvocally in auditory information storage (AIS). The rehearsal is, of course, auditory

rehearsal. Such a model could explain the finding that there was visual to auditory facilitation, but no auditory to visual facilitation, as follows. When S was presented with the visual task first, he not only stored the visual stimulus, but also rehearsed it subvocally. When he was presented subsequently with the auditory task, he had already practiced it (i.e., there was some subvocal rehearsal during the visual presentation). However, when S was presented with the auditory task first, while there could have been auditory rehearsal, it is unlikely that any visual rehearsal could have occured, since the visual representation of the stimulus was not present. Consequently, when he recieved the visual stimulus, it was, by comparison, a new task.

The second major purpose of this study was to examine possible characteristic differences in the performances of poor readers as compared to good readers in auditory and visual processing. From the sparse literature available, and from at least one theoretical viewpoint, there was reason to expect some differences, particularly in younger children and particularly in the auditory modality. More specifically, it was expected that younger poor readers would perform more poorly than younger good readers [illegible] tasks, but that the difference would be greater [illegible] auditory task.

These expectations were fully supported by the error data, since the younger poor readers made significantly more errors than the younger good readers on both sequencing tasks. Furthermore, the poor readers made significantly more errors in auditory sequencing than in visual sequencing, although this occurred only when the auditory task was presented first. These two groups did not differ on subtests 1 and 2 (single-letter stimuli). While latency of response was not significantly longer for the poor readers, there was a trend in that direction. Consequently, it can be stated that younger poor readers, while perhaps responding somewhat more slowly, nevertheless, were significantly less accurate than younger good readers, particularly in auditory sequencing. In general, no such differences occured between the older good and older poor readers. These results are consistent with the view that deficient perceptual skills may be of primary importance in determining reading difficulty at the earlier stages of reading instruction, but not at later stages (e.g., Katz, 1967; Reed, 1958; Rourke, Orr & Ridgely, 1974; Satz et al, 1971; Satz, Friel & Rudegeair, 1974).

That the younger poor readers were found to be deficient in these perceptual skills in comparison to good readers was not surprising, and adds further support to a well-established finding. What is more relevant

is the fact that only the younger poor readers demonstrated a relatively greater deficiency in auditory sequencing than in visual sequencing. This is in agreement with the findings of Katz (1967) for a discrimination task, and with the findings of Walters and Kosowski (1963) for a reaction-time task. It also lends further support to the view of Johnson and Myklebust (1962) that auditory-perceptual skills may be relatively more important for reading acquizition than was commonly believed.

What is the nature of this auditory deficit? In the present study, the skill which was tested was described as a complex skill involving not only attention and memory, but also discrimination and speed of recognition. What is interesting is that the younger good and poor readers did not differ on the first two subtests, which involved only single-letter stimuli, but which, nevertheless, also required the above-mentioned skills. The four-letter stimuli on which these groups did differ required the additional skill of temporal sequencing. This may well be the critical skill involved. This would make sense in view of the fact that sequencing is undoubtedly an important component of the reading process, particularly in its earlier stages.

However, since the six subtests were always presented in the same order, and since the younger poor readers

tended to perform most poorly on subtest 6, factors such as attention span and motivation must be considered. In fact, Walters and Kosowski (1963) found that, while retarded readers were poorer than average and advanced readers on an auditory reaction time task, this difference was not obtained under reward conditions. This suggested a possible motivational factor for poor readers during auditory tasks requiring sustained attention. A procedure in which the order of presentation of the various stimuli was counterbalanced might provide some clarification of these relationships. Such a procedure would necessitate the use of several films and tapes, since the order of presentation is relatively fixed in these.

The implications of the present findings for early education are fairly straightforward. It would seem to be very important to identify perceptual deficits at a pre-school age, paying particular attention to auditory processing. Conceivably, if such deficits could be identified earlier, remediation could begin prior to beginning reading instruction. This recommendation is in opposition to the views of many educators who promote a "hands-off" policy towards early identification and remediation. However, it is in direct agreement with the views expressed by those who have taken a serious look at the empirical findings (e.g., deHirsch, Jansky & Langford, 1966; Jansky & deHirsch, 1972).

It had been expected that the older poor readers might be somewhat poorer than good readers in auditory sequencing. As was stated above, in general no differences were found in the two older reading groups. However, a closer look at the results does reveal one significant difference. The poor readers did, in fact, make significantly more errors than the good readers on the auditory task but only on subtest 3 (fsbm), and only when the auditory task was presented first. It would seem that the sequence, fsbm, is the most difficult of all the stimuli. On the basis of this finding, it might be stated that if an older poor reader still has a perceptual deficit, it might pertain only to auditory sequencing of new and relatively difficult material. This finding seems worthy of further exploration, since little is known about deficits which might account for the persistence of poor reading skills in older children, despite the absence of significant perceptual problems.

The finding of a significant visual to auditory facilitation which was thought to be due to sub-vocal auditory rehearsal during the visual presentation would seem to suggest a further implication for early reading instruction particularly for remedial instruction. It would seem advisable when presenting visual material (e.g., flash

carefully allow the child to view the material longer than is the usual case and to have the child rehearse the material several times while viewing the stimuli.

APPENDIX A

REVIEW OF THE LITERATURE

The presence of relatively poorer auditory- and visual-perceptual skills in children with reading difficulties as compared to normal readers has been clearly established. Factors such as discrimination, sequencing, sensory integration and perceptual speed have been investigated either independently or in relation to other skills. In order to demonstrate the differences between good and poor readers in these skills one would merely have to select randomly from the countless studies available (e.g., Goins, 1958; Gibson, 1965; Johnson, 1957; Birch & Belmont, 1964; Doehring, 1968). A survey of this body of literature would shed little light on the specific questions posed in the present study. In most of this research direct comparisons between the auditory and visual modalities is impossible because the tasks employed have not been equivalent. What is clear in this research, however, is that both visual- and auditory-perceptual factors are consistently among the highest of those factors which discriminate between good and poor readers.

Most of the research comparing the visual and auditory modalities directly has been conducted on children having no reading difficulties. Furthermore, most of this research does not consist of studies in perceptual processes per se, but rather of studies in learning.

NORMAL READERS

Recall.

Studies of this type date back as far as the late nineteenth century. In one of the earliest studies, Kirkpatrick (1894) presented lists of words (names of common objects) visually and auditorally to pupils in all grades from grade 3 to college level. In the auditory presentation the words were pronounced at the rate of one every two seconds. In the visual presentation, the words, having been previously written on the chalkboard, were uncovered one at a time and rubbed out after two seconds. In a third condition they were shown common objects at the same rate. In each case, after ten words or objects were presented, the pupils were required to write down as many as they could recall. Three days later they were asked to write them down again. At all grade levels, both immediate and long-term memory for objects were significantly greater than for either auditorally- or visually- presented words. However, there were no differences at any grade level in the ability to recall the auditorally- or visually-presented words. With regard to this latter finding, Kirkpatrick's results recieved little support in subsequent studies

but his basic method provided an impetus for further research.

In a very similar study, Hawkins (1897) found that the auditory presentation was clearly more effective than the visual for children from grades 3 to 7, but that the visual presentation was superior for commercial students aged 15 to 20. Pohlman (1906) also found the auditory modality to be superior not only for words but also for numbers and for names of objects as compared to pictures of objects in children from grade 5 to grade 9.

An additional finding of the Pohlman study was that visual presentation of nonsense syllables resulted in greater learning than auditory presentation at all ages. Lockhard and Sidowski (1961) also found that nonsense syllables were learned more quickly visually than auditorally by fourth and sixth graders.

It appears that, in the learning situation where children are required to recall lists of words or nonsense syllables, the auditory modality tends to be more effective for learning words, while the visual modality is clearly more effective for learning nonsense syllables.

Paired-associate learning.

More recently, the two modalities have been compared on paired-associate learning tasks. Budoff and Quinlan (1964) presented second graders with nouns and verbs in several

paired combinations (noun-verb; verb-noun; noun-noun; verb-verb). The word-pairs were learned more quickly when presented auditorally than visually. Hill and Hecker (1966) observed that results such as those obtained by Budoff and Quinlan might be expected since young children were using a newly-acquired skill during the visual task, whereas in recognizing spoken words they were using a skill of long-standing. Hill and Hecker used picture-pairs representing words for the visual presentation and word-pairs for the auditory presentation. They found neither modality to be more effective. Unfortunately, their results were confounded since the children were required to name the objects during the visual presentation, effectively giving them the benifit of an auditory as well as a visual cue. However their observation may be a valid one.

Cooper and Gaeth (1967) found that for fourth, fifth, and sixth graders visual was superior to auditory learning of word-pairs, whereas for tenth and twelfth graders auditory presentation was more effective. This interaction was opposite to that proposed by McGeoch and Irion (1952) and Day and Beach (1950). It is difficult to explain Cooper and Gaeth's results since they conflict with most other findings. They also used nonsense syllable-pairs in their study and found the visual modality to be superior at all grade levels, a finding which is consistent with previous results.

Generally, for paired-associate tasks, non-meaningful

material (nonsense syllables) is learned more effectively visually than auditorally at all ages. This is consistent with the results in other types of learning tasks. Although meaningful material (word-pairs) tends to favour the auditory modality, the tendency is not as clear-cut as for the situation in which lists of words were learned.

Reading versus listening.

The relative proficiency of the visual and auditory modalities has also been determined by having children read and listen to passages after which comprehension is measured. Russell (1921) presented a 1000-word passage of general interest to pupils in grades 5, 7 and 9. In one condition, the teacher read the passage twice while the pupils listened. In a second condition, pupils were required to read the passage twice. In a third condition, pupils were required to read the passage at their own rate but were given as much time as in the listening condition. Listening proved to be more effective for fifth graders, there was no difference in the seventh grade, and reading was more effective in the ninth grade. Hsia (1968) also found no differences in reading or listening for seventh graders. For Many (1965) sixth graders profited more from reading than from listening.

By far the most exhaustive investigation of this question was done by Durrell (1969). He covered all grades from

1 to 8 using approximately 3000 to 4000 pupils per grade. His results showed a definite interaction of age and modality. Listening was superior from grade 1 to grade 5 while reading was superior from grade 6 to grade 8.

Despite some conflicting evidence, generally the conclusions of McGeoch and Irion (1952) and Day and Beach (1950) were upheld when listening was compared with reading. Listening is superior for younger children; however, reading becomes increasingly more effective with age until, at approximately age 11 or 12, reading becomes superior and remains so thereafter.

POOR READERS

There has been very little research comparing visual- and auditory-perceptual abilities in poor readers. In good readers most of the studies centered on learning efficiency. Significantly, in the case of poor readers, the majority of studies have centered on perceptual processing.

Katz (1967) gave second, fourth, and sixth grade normal and retarded readers two discrimination tasks in both modalities. One task involved discriminating between pairs of one syllable English words, the other involved discriminating between pairs of one syllable Hebrew words. The normal readers were clearly superior to the retarded readers in all

instances, the clearest separation being obtained at the second grade level. In both groups, auditory discrimination was superior for Hebrew words, while visual discrimination was superior for English words. An earlier study by the same author (Katz & Deutsch, 1964) revealed similar results. These results conflict with the results of the majority of studies with normal readers. In those studies reviewed which employed normal readers only, the opposite relationship occured, i.e., the auditory modality was more effective for meaningful material whereas the visual modality was more effective for non-meaningful, more difficult material. Katz suggested that a lack of equivalence in familiarity between the Hebrew auditory and Hebrew visual words might account to some extent for the opposite interaction. Another possible explanation might be offered, i.e., there was one notable difference between both of the Katz studies and the other investigations. In the Katz studies, the subjects were drawn from a population of negro males from a very low socio-economic area, whereas in the other investigations middle-class white children were used.

A significant finding in the Katz (1967) study was that the difference between the normal and retarded readers in auditory discrimination of Hebrew words was greater than the difference in visual discrimination. This does suggest the possibility of a characteristic difference between good and poor readers in the relative efficiency of the visual and

auditory modalities.

Katz also found that her discrimination tasks separated normal from retarded readers most clearly at the grade two level and that this difference was least in grade six. This finding lends support to the view of Reed (1958) and Rourke, Orr and Ridgely (1973) that deficient perceptual skills may be of primary importance in determining reading disability at the earlier stages of reading instruction; whereas a deficiency in other higher order skills (e.g., symbolic processing) may be more significant at a later stage. There is some reason to suspect that this view may apply more readily to visual-perceptual skills than in the case of auditory-perceptual skills. In the Rourke, Orr and Ridgely (1973) study which was part of a longitudinal investigation including the original study by Ridgely and Rourke (1971), the retarded readers were initially (at age 7) comparatively deficient in both visual- and auditory-perceptual skills. While they continued to perform more poorly than the normal readers with advancing years, they made greater gains in visual- than in auditory-perceptual ability. That is to say, at age 11 the retarded readers differed from normal readers to a greater extent on auditory-perceptual tests than on visual-perceptual tests. Additionally, in a clinical setting, the present author has repeatedly noted that the performances of older (11 and 12 year-old) children who have severe

reading difficulties tend to be clearly more impaired on auditory-perceptual tests than on tests measuring visual-perceptual skills.

Muehl and Kremenak (1966), using dot and tone patterns similar to those employed in the auditory-visual integration studies (e.g., Birch & Belmont, 1964) presented four matching tasks to first graders at the beginning of the school year. The tasks included visual-visual, visual-auditory, auditory-visual, and auditory-auditory matching. Reading achievement was measured at the end of the school year and extreme reading groups were selected and matched for IQ on the Lorge-Thorndike Intelligence Test. While both the visual-auditory and auditory-visual (between modality) tasks predicted later reading achievement, the correlation between visual-auditory matching and reading was considerably higher than that between auditory-visual matching and reading. Although neither of the within-modality tasks contributed to predicting later reading achievement, matching visual pairs was the easiest of all four tasks for all children while matching auditory pairs was the most difficult. This indicates a marked superiority of the visual modality over the auditory modality for the perception of non-verbal sequential material in young children regardless of reading proficiency. Fillmer and Linder (1970) also found that visual perception was better than auditory perception for non-verbal material among poor readers.

Their second grade poor readers were more proficient in recalling color sequences presented visually than they were in recalling the names of the sequences presented auditorally. While retarded readers in grades 6, 7, and 8 performed as well as average and advanced readers on a visual reaction-time task (colored lights), they were poorer on an auditory reaction-time task (pure tones) in a study by Walters and Rosowski (1963). However, their retarded readers who were given rewards did as well as the average and advanced readers on both tasks, whereas the average and advanced readers did not profit from the rewards. This introduces a possible motivational factor for poor readers during auditory perceptual tasks requiring sustained attention.

While the research comparing visual- and auditory- perceptual skills in poor readers has been scant, several observations can be made. First, the difference between good and poor readers in both visual- and auditory- perceptual ability appears to be greater in younger than in older children. Secondly, the difference between auditory and visual perception of less meaningful material may be greater in poor readers than in good readers. That is to say, poor readers may be relatively poorer in auditory-perceptual ability as compared to visual-perceptual ability than is the case for normal readers. However a motivational factor may account for this difference. Thirdly, when the stimuli are non-verbal and

sequential, and when a matching response is required, the visual modality is superior to the auditory in poor as well as in good readers.

In summarizing the research in which the visual and auditory modalities have been compared directly, it should be pointed out that the results are frequently obscurred and sometimes conflicting because of several factors. Sample size and population characteristics differed considerably in many cases. In many of the earlier studies, a very minimal number of subjects was used. Although most investigators employed unbiased populations, several used highly specific populations. Frequently, the tasks were not comparable from one study to another-- there were differences in the level of difficulty of material and response measures. In many instances, the auditory task and the visual task lacked "equivalency" in both stimulus and response characteristics. In the investigations of normal populations, the task in most instances was a learning task, whereas in the investigations of poor readers the task was usually a perceptual one.

Despite these differences, several generalizations are possible, as follows.

1. For both good and poor readers, when the individual stimuli contain more than single elements (e.g., nonsense syllables), the visual modality is clearly superior to the auditory for non-meaningful material at all ages. When single stimuli

(e.g., lights and tones) are employed, there may not be any difference in perception.

2. For both good and poor readers, auditory-perceptual skill tends to be superior for meaningful material (e.g., words and stories). However, this difference decreases with age and, in the case of stories, the visual modality becomes more effective after the age of 11 or 12.

3. The difference between good and poor readers in both visual- and auditory-perceptual ability appears to be greater in younger than in older children.

4. For poor readers, auditory-perceptual ability may be somewhat poorer than visual in older children than it was at the beginning of reading instruction.

5. The difference between auditory- and visual-perceptual abilities may be greater for poor readers than for good readers at all ages.

SPEED OF PERCEPTION

Speed of perception has recieved little attention in studies of reading disabled children. The studies that are reported have concentrated almost entirely on visual perception.

An extensive and fairly exhaustive investigation into the neuropsychological abilities of older normal and retarded

readers (aged 9-14) was carried out by Doehring (1968). Approximately 103 individual dependent measures were employed in this study, ranging from simple motor skills through perceptual and verbal to intellectual and cognitive skills. While the retarded readers were inferior to the normal readers on a great number of abilities (62 of the 103 measures), by means of several multiple correlational techniques Doehring was able to isolate a cluster of abilities which discriminated between the groups most clearly. The predominant pattern of deficit was characterized by "... and interaction of visual and verbal impairment involving both verbal and non-verbal visual skills and both visual- and auditory-verbal skills." Among the individual tests which separated the groups most clearly was a test which Doehring developed specifically for this investigation and which he called the Speed of Visual Perception Test. This test consists of 13 individual subtests involving verbal and non-verbal stimuli varying in complexity and meaningfulness. The stimuli include individual nonsense forms, gestalt forms, individual numbers and letters, sequences of geometric forms, and sequences of letters. On each subtest the subject is required to find a particular stimulus or stimulus configuration on a page which is filled with lines of related stimuli and to underline it as quickly as possible. The correct stimulus appears randomly throughout the series. For instance, on one subtest

various single letters of the alphabet are arranged randomly on a page, 20 letters to a line, 18 lines to a page. On this subtest, the subject must underline all the S's as quickly as he can. On another subtest, the correct stimulus is a four-letter unit such as narp, while the other stimuli consist of various combinations of the same four letters (e.g., prna, npra, etc.). On each subtest, a sample of the correct stimulus is given at the top of the page. A preliminary test is given consisting of an illustration of the stimulus to be identified, an example of a sequence of test figures in which this stimulus is underlined, and a short series of practice items. Examples of the 13 subtests taken from Dudley, Doehring, and Coderre (1968), with the correct item underlined, are contained in Appendix A.

Ridgely and Rourke (1971) conducted an investigation highly similar to Doehring's (1968) study employing the same and additional tests, but with younger normal and retarded readers (aged 7-8). The results were highly similar to those obtained by Doehring, indicating a considerable number of impaired skills in young retarded readers as well. Again the Speed of Visual Perception Test was among the tests which discriminated between the normal and retarded readers most clearly. In fact, this test separated the two groups almost as well as did the reading tests. In a three-year follow-up study of the same children (Rourke, Orr & Ridgely, 1973) two

groups of retarded readers were selected. One group consisted of those children who had improved most in reading, the other consisting of those who had made the least improvement. These two groups were then compared on their original performances in the initial study (Rid[illegible] & Rourke, 1971). The Speed of Visual Perception Test and only one other test of all 103 measures contributed to predicting later reading achievement. On the Speed of Visual Perception Test the performance of the most-improved group exceeded that of the least-improved group on all 13 subtests. The difference was highly significant in the case of 7 of the subtests. This finding is particularly compelling in view of the fact that none of the reading tests contributed to predicting later reading achievement. It goes without saying that speed of visual perception appears to be highly associated with reading ability, particularly in young children.

APPENDIX B

EXAMPLES OF THE 13 SUBTESTS WITH THE CORRECT UNIT UNDERLINED. SPEED OF VISUAL PERCEPTION TEST (DUDLEY, DOEHRING & CODERRE, 1968)

1	1 8 9 4 2 7 6 4 3 5
2	
3	
4	
5	v u s p f t s e s u c d
6	geyg finj hbjs pwzl vppi raie
7	h g i b t d m e m t o b
8	
9	sfmb bfms sbmf fsbm fmbs
10	aprn apnr parn narp aprn rapn
11	post tops stop spot sotp psot
12	t o p s s t o p s p o t s
13	1 3 0 5 2 7 6 5 3 4

APPENDIX C

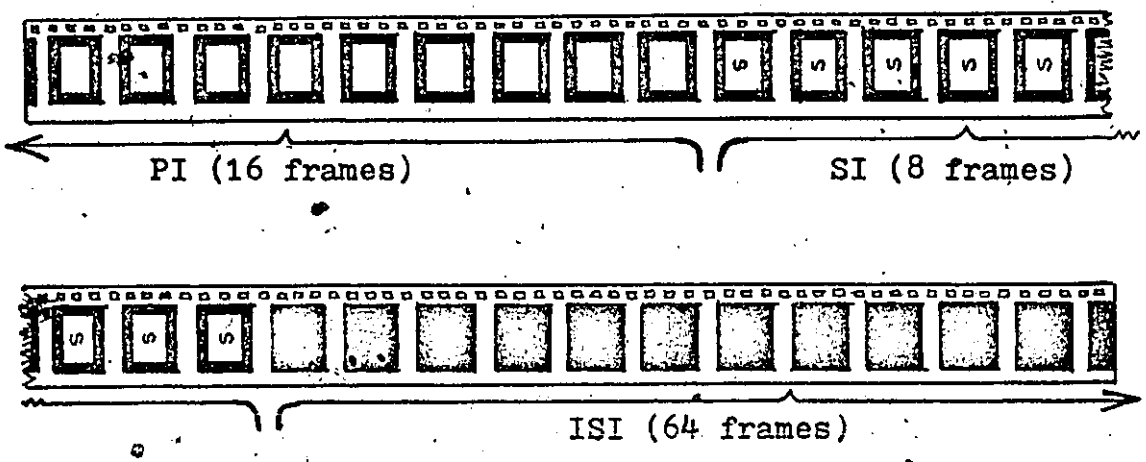
EXAMPLES OF THE SIX SUBTESTS ADAPTED FROM THE SPEED OF VISUAL PERCEPTION TEST WITH THE CORRECT UNIT UNDERLINED

1	d	s	e	g	h	s	v	e	s	m
2	u	m	i	b	t	d	m	b	k	r
3	sbmf	fsbm	bmsf	fbms	mbsf	fsbm				
4	rnap	prna	narp	aprn	narp	napr				
5	psot	spot	tops	spot	post	stop				
6	nest	ntes	sent	tens	nest	sten				

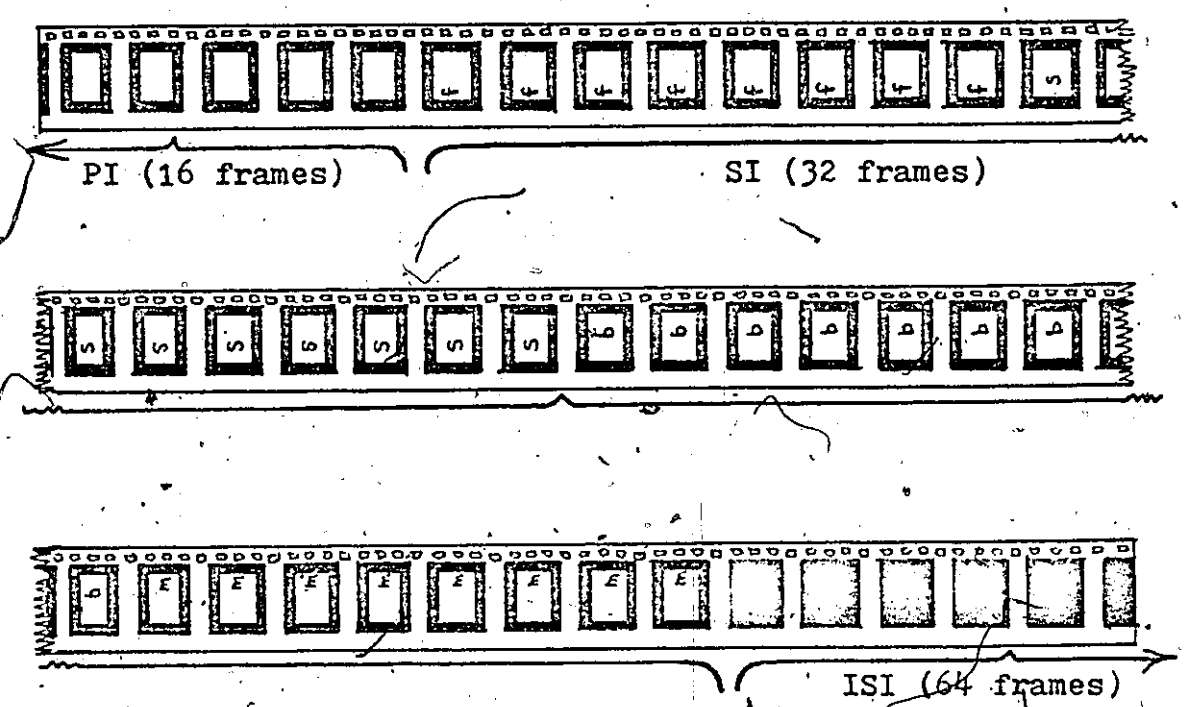
APPENDIX D

EXAMPLES OF SECTIONS OF FILM FOR (a) SINGLE-LETTER STIMULI AND (b) FOUR-LETTER SEQUENCES SHOWING THE PREPARATORY INTERVAL (PI), THE STIMULUS INTERVAL (SI), AND THE INTER-STIMULUS INTERVAL (ISI)

(a)

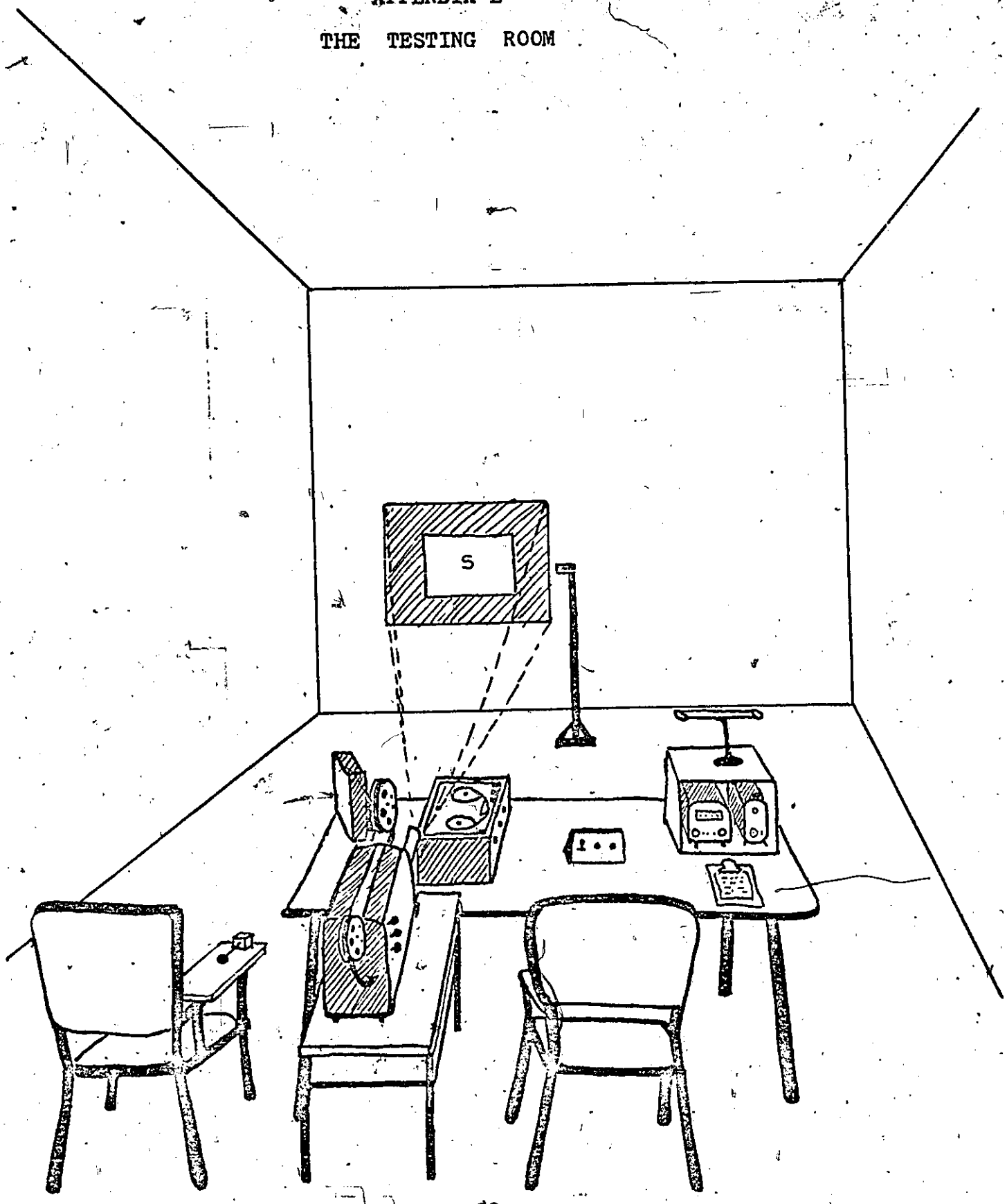


(b)



APPENDIX E

THE TESTING ROOM



APPENDIX F

INSTRUCTIONS

SVPT

These tests will involve LOOKING AT separate letters such as p and z and also groups of letters such as oadl. There are six different tests. In each test you will SEE many different letters or different groups of letters, but on each test only one letter or group of letters will be the correct one. Before each test begins I will SHOW you the correct one. I will also SHOW you other letters or groups of letters which are not correct. Then you will have a short practice session before beginning the test. You will be asked to press this (demonstrate) lever as quickly as you can recognise the correct letter or group of letters, but you are not to press the lever for any other letter or group.

Subtests

(1) On the first test the correct letter is (SHOW s), but you will SEE many other letters also. Every so often you will SEE an (SHOW s); for example d,s,e,t,s,. Whenever you SEE the correct letter, you are to press the lever as quickly as you can. Don't press the lever for any other letter, but if you do, don't worry about it, just wait for the next letter.

We'll have some practice now before we begin the test. Remember to press only for (SHOW s), remember (SHOW s).
v,u,s,p,f,t,s,e,s,u,.

Now we'll begin the Test. Remember the correct letter is (SHOW s).
s,u,c,d,s,y,c,s,s,e,h,g,g,s,k,.

(2) On this test instead of one letter being correct, two letters are correct. You are to press the lever whenever you SEE either (SHOW b or m); for example, t,b,l,a,m,.

Now we'll have some practice before we begin the test. Remember to press for either (SHOW b or m), remember (SHOW b or m).
b,q,h,m,r,m,e,g,b,t,.

Now we'll begin the Test. Remember, either (SHOW b or m) is correct. r,j,m,b,g,u,b,t,n,k,m,d,y,b,s,.

(3) This test will be a bit more difficult so I want you to pay very close attention. This time, instead of pressing the lever for a separate letter, you are to press it only after you SEE a group of letters. It will be a group of four letters arranged in a certain order. The correct group is (SHOW fsbm). The other groups are made up of the same four letters but the letters are not in the same order. For example, sfmb, bfms, sbmf, fsbm, fmbs,.

We'll have some practice. Remember to press for (SHOW fsbm), remember (SHOW fsbm). sfbm, fsbm, smfb, fmbs, fsbm, mbfs, mfsb, fmsb, fsbm, bfms,.

Now we'll begin the TesT. Remember, the correct group is (SHOW fsbm). fmsb, bsmf, sfmb, fsbm, fmbs, fsbm, mfbs, mbsf, fsbm, sfbm, fsbm, bmfs, fsbm, bfsm, sbmf,.

(4) This test ~~will~~ be like the last one but this time the correct group is (SHOW narp). The other groups are made up of the same four letters but again the letters are not in the same order. For example, ranp, apnr, narp, parn, aprn,.

We'll have some practice. Remember to press only for (SHOW narp), remember (SHOW narp). rnap, narp, pran, anrp, parn, narp, anrp, narp, nrap, parn,.

Now we'll begin the Test. Remember the correct group is (SHOW narp). narp, arpn, prna, nrpa, narp, nrpa, arpn, rnpa, pran, narp, ranp, narp, apnr, rpna, narp,.

(5) On this test the correct group is (SHOW spot). Again the letters will be the same ones but they will have a different order in the other groups. For example, post, spot, stop, tops, sotp,.

We'll have some practice. Remember to press only for (SHOW spot), remember, (SHOW spot). pots, spot, tpos, psot, spot, spto, psot, spot, spot, post,.

Now we'll begin the test. Remember the correct group is (SHOW spot).
tops, spot, psot, spot, spto, stop, sopt, tpos, spot, spot,
pots, post, tops, spot,.

(6) On this test the correct group is (SHOW nest). Again these letters will have a different order in the other groups. For example, sent, tens, nest, nets, ntes,.

We'll have some practice. Remember to press only for (SHOW nest), remember (SHOW nest). tens, tnes, nest, sten, nest, nets, stne, nest, sent, ntes,.

Now we'll begin the test. Remember the correct group is (SHOW nest).
sent, stne, nest, ntes, nest, sten, nets, nest, nets, tens, tesn, sten, nest, sent, nest,.

SAPT

These tests will involve LISTENING TO separate letters such as p and z and also groups of letters such as oadl. There are six different tests. In each test you will HEAR many different letters or different groups of letters, but on each test only one letter or group of letters will be the correct one. Before each test begins I will TELL you the correct one. I will also TELL you other letters or groups of letters which are not correct. Then you will have a short practice session before beginning the test. You will be asked to press this (demonstrate) lever as quickly as you can recognise the correct letter or group of letters, but you are not to press the lever for any other letter or group.

Subtests

(1) On the first test the correct letter is (SAY s), but you will HEAR many other letters also. Every so often you will HEAR an (SAY s); for example d,s,e,t,s,. Whenever you HEAR the correct letter, you are to press the lever as quickly as you can. Don't press the lever for any other letter, but if you do, don't worry about it, just wait for the next letter.

We'll have some practice now before we begin the test. Remember to press only for (SAY s), remember(SAY s).
v,u,s,p,f,t,s,e,s,u,.

Now we'll begin the Test. Remember the correct letter is (SAY s).
s,u,c,d,s,y,c,s,s,e,h,q,g,s,k,.

(2) On this test instead of one letter being correct, two letters are correct. You are to press the lever whenever you HEAR either (SAY b or m); for example, t,b,l,a,m,.

Now we'll have some practice before we begin the test. Remember to press for either (SAY b or m), remember (SAY b or m).
b,q,h,m,r,m,e,g,b,t,.

Now we'll begin the Test. Remember, either (SAY b or m) is correct. r,j,m,b,g,u,b,t,n,k,m,d,y,b,s,.

(3) This test will be a bit more difficult so I want you to pay very close attention. This time, instead of pressing the lever for a separate letter, you are to press it only after you HEAR a group of letters. It will be a group of four letters arranged in a certain order. The correct group is (SAY fsbm). The other groups are made up of the same four letters but the letters are not in the same order. For example, sfmb, bfms, sbmf, fsbm, fmbs,.

We'll have some practice. Remember to press for (SAY fsbm), remember (SAY fsbm). sfbm, fsbm, smfb, fmbs, fsbm, mbfs, mfsb, fmsb, fsbm, bfms,.

Now we'll begin the Test. Remember, the correct group is (SAY fsbm). fmsb, bsmf, sfmb, fsbm, fmbs, fsbm, mfbs, mbsf, fsbm, sfbm, fsbm, bmfs, fsbm, bfsm, sbmf,.

(4) This test will be like the last one but this time the correct group is (SAY narp). The other groups are made up of the same four letters but again the letters are not in the same order. For example, ranp, apnr, narp, parn, aprn,.

We'll have some practice. Remember to press only for (SAY narp), remember (SAY narp). rnap, narp, pran, anrp, parn, narp, anrp, narp, nrap, parn,.

Now we'll begin the Test. Remember the correct group is (SAY narp). narp, arpn, prna, nrpa, narp, nrpa, arpn, rnpa, pran, narp, ranp, narp, apnr, rpna, narp,.

(5) On this test the correct group is (SAY spot). Again the letters will be the same ones but they will have a different order in the other groups. For example, post, spot, stop, tops, sotp,.

We'll have some practice. Remember to press only for (SAY spot), remember, (SAY spot). pots, spot, tpos, psot, spot, spto, psot, spot, spot, post,.

Now we'll begin the test. Remember the correct group is (SAY spot). tops, spot, psot, spot, spto, stop, sopt, tpos, spot, spot, pots, post, tops, spot,.

(6) On this test the correct group is (SAY nest). Again these letters will have a different order in the other groups. For example, sent, tens, nest, nets, ntes,.

We'll have some practice. Remember to press only for (SAY nest), remember (SAY nest). tens, tnes, nest, sten, nest, nets, stne, nest, sent, ntes,.

Now we'll begin the test. Remember the correct group is (SAY nest). sent, stne, nest, ntes, nest, sten, nets, nest, nets, tens, tesn, sten, nest, sent, nest,.

APPENDIX G

Table 6

Summary of Analysis of Variance of Latency of Response for Age, Reading Level, Order of Presentation, Modality and Complexity (Subtests 1 & 2)

Source	df	MS	F
Between Ss			
(A) Age	1	1.419	36.58***
(B) Reading Level	1	0.012	
(C) Order	1	0.060	1.55
A X B	1	0.029	
A X C	1	0.014	
B X C	1	0.086	2.21
A X B X C	1	0.002	
Error	56	0.039	
Within Ss			
(D) Modality	1	0.040	2.16
A X D	1	0.045	2.41
B X D	1	0.001	
C X D	1	0.005	
A X B X D	1	0.025	1.36
A X C X D	1	0.003	
B X C X D	1	0.075	4.09*
A X B X C X D	1	0.016	
Error	56	0.019	
(E) Complexity	1	0.451	55.63***
A X E	1	0.021	2.59
B X E	1	0.002	
C X E	1	0.000	
A X B X E	1	0.000	
A X C X E	1	0.006	
B X C X E	1	0.001	
A X B X C X E	1	0.007	
Error	56	0.008	
D X E	1	0.021	4.20*
A X D X E	1	0.012	2.37
B X D X E	1	0.001	
C X D X E	1	0.008	1.53

Table 6 continued

A X B X D X E	1	0.000	
A X C X D X E	1	0.014	2.82
B X C X D X E	1	0.000	
A X B X C X D X E	1	0.004	
Error	56	0.005	

* $p < .05$
*** $p < .001$

Table 7

Summary of Analysis of Variance of the Simple Effects of Modality X Complexity Interaction for Latency of Response for Subtests 1 and 2

Source	df	MS	F
(D) Modality for			
(e_1) Complexity level 1	1	0.059	5.05*
D for e_2	1	0.002	
Error	112	0.012	
(E) Complexity for			
(d_1) Visual	1	0.139	21.40***
E for (d_2) Auditory	1	0.332	51.09***
Error	112	0.007	

* $p < .05$
*** $p < .001$

Table 8

Summary of Analysis of Variance of the Simple Effects of Reading Level X Order X Modality Interaction for Latency of Response for Subtests 1 and 2

Source	df	MS	F
(C) Order X (D) Modality for			
(b_1) Younger	1	0.145	5.04*
C X D for (b_2) Older	1	0.015	
Error	112		
C for (d_1) Visual	1	0.049	1.73
C for (d_2) Auditory	1	0.001	
Error	112	0.029	
D for (c_1) Order 1	1	0.003	
D for (c_2) Order 2	1	0.099	5.35*
Error	56	0.019	

* $p < .05$

Table 9

Summary of Analysis of Variance of Latency of Response for Age, Reading Level, Order of Presentation, Modality and Complexity (Subtests 3, 4, 5, & 6)

Source	df	MS	F
Between Ss			
(A) Age	1	15.246	60.31***
(B) Reading Level	1	0.412	1.63
(C) Order	1	1.844	7.26**
A X B	1	0.148	
A X C	1	0.039	
B X C	1	0.066	
A X B X C	1	0.035	
Error	56	0.252	
Within Ss			
(D) Modality	1	7.958	82.46***
A X D	1	0.142	1.47
B X D	1	0.250	2.60
C X D	1	0.811	8.40**
A X B X D	1	0.017	
A X C X D	1	0.109	1.14
B X C X D	1	0.015	
A X B X C X D	1	0.125	1.29
Error	56	0.097	
(E) Complexity	3	0.219	5.98*
A X E	3	0.072	1.95
B X E	3	0.029	
C X E	3	0.009	
A X B X E	3	0.032	
A X C X E	3	0.012	
B X C X E	3	0.017	
A X B X C X E	3	0.013	
Error	168	0.037	
D X E	3	0.069	3.24*
A X D X E	3	0.007	
B X D X E	3	0.027	1.25
C X D X E	3	0.052	2.44

Table 9 continued

A X B X D X E	3	0.074	3.46*
A X C X D X E	3	0.009	
B X C X D X E	3	0.010	
A X B X C X D X E	3	0.020	
Error	168	0.021	

* $p < .05$
** $p < .01$
*** $p < .001$

Table 10

Summary of Analysis of Variance of the Simple Effects of Order X Modality Interaction for Latency of Response for Subtests 3, 4, 5, & 6

Source	df	MS	F
(D) Modality for			
(c_1) Order 1	1	1.650	17.09*
D for (c_2) Order 2	1	8.732	90.49***
Error	56	0.097	
(C) Order for (d_1) Visual	1	0.006	
C for (d_2) Auditory	1	2.550	14.61*
Error	112		

* $p < .05$
*** $p < .001$

Table 11

Summary of Analysis of Variance of Latency of Response of Younger Ss as a function of Reading Level, Modality, and Complexity (Subtests 3, 4, 5, and 6)

Source	df	MS.	F
Between Ss			
(B) Reading Level	1	0.527	2.19
Error	30	0.241	
Within Ss			
(D) Modality	1	2.988	37.31***
B X D	1	0.198	2.47
Error	30	0.080	
(E) Complexity	3	0.126	2.50
B X E	3	0.047	
Error	90	0.050	
D X E	3	0.026	
B X D X E	3	0.077	1.56
Error	90	0.049	

*** $p < .001$

Table 12

Summary of Analysis of Variance of Latency of Response of Older Ss as a Function of Reading Level, Modality and Complexity (Subtests 3, 4, 5 & 6)

Source	df	MS	F
Between Ss			
(B) Reading Level	1	0.033	
Error	30	0.296	
Within Ss			
(D) Modality	1	5.111	59.22***
B X D	1	0.069	
Error	30	0.086	
(E) Complexity	3	0.166	9.26**
B X E	3	0.014	
Error	90	0.018	
D X E	3	0.050	4.23**
B X D X E	3	0.024	1.99
Error	90	0.012	

** $p < .01$
*** $p < .001$

Table 13

Summary of Analysis of Variance of Simple Effects of Modality X Complexity Interaction for Latency of Response of Older Ss (Subtests 3, 4, 5, & 6)

Source	df	MS	F
(D) Modality for (e_3)			
Complexity level 3	1	0.846	21.11***
D for e_4	1	0.929	23.16***
D for e_5	1	1.588	39.59***
D for e_6	1	1.898	47.32***
Error	224	0.040	
(E) Complexity for			
(d_1) Visual	3	0.034	1.16
E for (d_2) Auditory	3	0.182	6.27**
Error	336	0.029	

** $p < .01$
*** $p < .001$

Table 14

Newman-Keuls Test of the Differences Between all Pairs of Means for Latency of Response of Older Ss on the SAPT (Subtests 3, 4, 5, & 6)

	6	5	4	3
6	----	0.01	0.08*	0.16*
5	----	----	0.07	0.15*
4	----	----	----	0.08

* $p < .05$

Table 15

Summary of Analysis of Variance of Error Scores for Age, Reading Level, Order, Modality and Complexity (Subtests 1, 2, 3, 4, 5 & 6)

Source	df	MS	F
Between Ss			
(A) Age	1	6.053	63.31***
(B) Reading Level	1	1.765	18.46***
(C) Order	1	1.008	10.54**
A X B	1	1.534	16.04***
A X C	1	0.126	1.32
B X C	1	0.292	3.05
A X B X C	1	0.035	
Error	56	0.096	
Within Ss			
(D) Modality	1	0.127	
A X D	1	0.234	1.64
B X D	1	0.347	2.43
C X D	1	0.848	5.95*
A X B X D	1	0.014	
A X C X D	1	0.427	2.99
B X C X D	1	0.444	3.11
A X B X C X D	1	0.026	
Error	56	0.143	
(E) Complexity	5	0.426	4.49***
A X E	5	0.261	2.76*
B X E	5	0.236	2.49*
C X E	5	0.072	
A X B X E	5	0.097	1.02
A X C X E	5	0.019	
B X C X E	5	0.118	1.24
A X B X C X E	5	0.035	
Error	280	0.095	
D X E	5	0.245	5.27***
A X D X E	5	0.206	4.41***
B X D X E	5	0.053	1.14
C X D X E	5	0.039	

Table 15 continued.

A X B X D X E	5	0.120	2.57*
A X C X D X E	5	0.131	2.81*
B X C X D X E	5	0.075	1.62
A X B X C X D X E	5	0.195	4.19***
Error	280	0.047	

* $p < .05$
** $p < .01$
*** $p < .001$

Table 16

Summary of Analysis of Variance of Error Scores of Younger Ss for Reading Level, Order, Modality and Complexity

Source	df	MS	F
Between Ss			
(B) Reading Level	1	3.295	22.44***
(C) Order	1	0.923	6.29*
B X C	1	0.264	1.80
Error	28	0.147	
Within Ss			
(D) Modality	1	0.352	1.70
B X D	1	0.249	1.21
C X D	1	1.239	5.99*
B X C X D	1	0.128	
Error	28	0.207	
(E) Complexity	5	0.519	4.11**
B X E	5	0.241	1.91
C X E	5	0.087	
B X C X E	5	0.022	
Error	140	0.126	
D X E	5	0.376	4.92**
B X D X E	5	0.093	1.22
C X D X E	5	0.031	
B X C X D X E	5	0.292	3.83**
Error	140	0.076	

* $p < .05$
** $p < .01$
*** $p < .001$

Table 17

Summary of Analysis of Variance of Error Scores of Younger Ss for Reading Level, Modality and Complexity for Order I

Source	df	MS	F
Between Ss			
(B) Reading Level	1	3.69	19.42***
(D) Modality	1	1.52	7.99**
B X D	1	1.77	9.30**
Error	21	0.19	
Within Ss			
(E) Complexity	5	0.28	2.52*
B X E	5	0.13	1.19
D X E	5	0.42	3.85**
B X D X E	5	0.20	1.79
Error	140	0.11	

* p .05
** p .01
*** p .001

Table 18

Summary of Analysis of Variance of Simple Effects of Reading Level X Modality Interaction (Error Scores of Younger Ss for Order I)

Source	df	MS	F
(B) Reading Level for (d_1) Visual	1	0.067	5.18*
B for (d_2) Auditory	1	0.366	28.12***
Error	28	0.013	
(D) Modality for (b_1) Good Readers	1	0.010	
D for (b_2) Poor Readers	1	0.509	15.91**
Error	14	0.032	

* $p < .05$
** $p < .01$
*** $p < .001$

Table 19

Summary of Analysis of Variance of Simple Effects of Modality X Complexity Interaction (Error Scores of Younger Ss for Order I)

Source	df	MS	F
(D) Modality for (e_1)			
Complexity level 1	1	0.017	
D for e_2	1	0.198	1.71
D for e_3	1	0.613	5.29*
D for e_4	1	0.349	3.01
D for e_5	1	0.468	4.04*
D for e_6	1	1.475	12.72**
Error	84	0.116	
(E) Complexity for			
(d_1) Visual	5	0.090	1.42
E for (d_2) Auditory	5	0.497	7.72***
Error	140	0.064	

* $p < .05$
** $p < .01$
*** $p < .001$

Table 20

Newman-Keuls Test of the Differences Between all Pairs of Means for Error Scores of Younger Ss on the SAPT on subtests 1, 2, 3, 4, 5, and 6 for Order I

	1	2	4	5	3	6
1	----	0.07	0.27*	0.33*	0.39*	0.41*
2	----	----	0.20*	0.26*	0.32*	0.34*
4	----	----	----	0.06	0.12	0.14
5	----	----	----	----	0.06	0.08
3	----	----	----	----	----	0.02

* $p < .05$

Table 21

Summary of Analysis of Variance of Error Scores of Younger Ss for Reading Level, Modality and Complexity for Order II

Source	df	MS	F
Between Ss			
(B) Reading Level	1	0.75	4.98*
(D) Modality	1	0.18	1.19
B X D	1	0.13	
Error	21	0.15	
Within Ss			
(E) Complexity	5	0.23	2.31*
B X E	5	0.31	3.07*
D X E	5	0.11	1.11
B X D X E	5	0.12	1.14
Error	140	0.10	

* p < .05

Table 22

Summary of Analysis of Variance of Simple Effects of Reading Level X Complexity Interaction (Error Scores of Younger Ss for Order II)

Source	df	MS	F
(B) Reading Level for			
(e_1) Complexity level 1	1	0.020	
(e_2)	1	0.359	4.39*
(e_3)	1	0.596	7.18*
(e_4)	1	0.088	1.06
(e_5)	1	0.006	
(e_6)	1	0.091	1.09
Error	84	0.083	

* $p < .05$

Table 23

Summary of Analysis of Variance of Error Scores of Older Ss for Reading Level, Order, Modality and Complexity

Source	df	MS	F
Between Ss			
(B) Reading Level	1	0.004	
(C) Order	1	0.211	4.74*
B X C	1	0.062	1.40
Error	28	0.044	
Within Ss			
(D) Modality	1	0.008	
B X D	1	0.111	1.59
C X D	1	0.036	
B X C X D	1	0.341	4.88*
Error	28		
(E) Complexity	5	0.168	3.11*
B X E	5	0.092	1.71
C X E	5	0.054	1.00
B X C X E	5	0.079	1.46
Error	140	0.054	
D X E	5	0.105	3.75**
B X D X E	5	0.050	1.79
C X D X E	5	0.059	2.10
B X C X D X E	5	0.060	2.12
Error	140	0.028	

* $p < .05$
** $p < .01$

Table 24

Summary of Analysis of Variance of Simple Effects of Modality X Complexity Interaction for Error Scores of Older Ss

Source	df	MS	F
(D) Modality for (e_1)			
Complexity level 1	1	0.066	1.88
D for e_2	1	0.029	
D for e_3	1	0.282	8.06**
D for e_4	1	0.004	
D for e_5	1	0.000	
D for e_6	1	0.219	6.27*
Error	168	0.035	
(E) Complexity for			
(d_1) Visual	5	0.099	2.44*
E for (d_2) Auditory	5	0.173	4.23**
Error	280	0.041	

* $p < .05$
** $p < .01$

Table 25

Summary of Analysis of Variance of Simple Effects of Reading Level X Order X Modality Interaction for Error Scores of Older Ss

Source	df	MS	F
(C) Order X (D) Modality for (b_1) Good Readers	1	0.022	
C X D for (b_2) Poor Readers	1	0.251	4.39*
Error	56	0.057	

* $p < .05$

Table 26

Summary of Analysis of Variance of Simple Effects of Order X Modality Interaction for Error Scores of Older Poor-Reading Ss

Source	df	MS	F
(C) Order for			
(d_1) Visual	1	0.008	
C for (d_2) Auditory	1	0.261	5.32*
Error	28	0.049	

* $p < .05$

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