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To investigate the underlying factors of visual discrimination, memory, rule abstraction, language, and serial ordering in reading success, 79 poor and 65 good deaf readers were administered a battery of tests. Poor readers were deficient in lower-order visual discrimination and memory abilities; higher-order visual discrimination skills were important to success for good readers. Higher-order rule abstraction skills were important for continued progress by the relatively successful readers, however, lower-order rule abstraction was important to successful visual discrimination at initial levels of reading for poor readers as well. Successful rule abstraction was significant at all levels of reading; and visual discrimination (visual search and sequencing) was significant to the advanced reader for the processing of higher-level printed text. Implications were that rule abstraction is important at all levels of the reading process, visual discrimination activities at prereading and higher reading levels should be re-evaluated, and investigation is needed to determine sentence structures that are obstacles to progress beyond intermediate levels of reading. (Author/RJ)

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U. S. DEPARTMENT OF
HEALTH, EDUCATION, AND WELFARE

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Identification, Assessment and Prediction of Reading Competency in Deaf Children

Lillian C. R. Restaino

Lexington School for the Deaf

New York, N. Y.

December 1968

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U. S. DEPARTMENT OF
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SUMMARY

This investigation was concerned with the definition of underlying factors in the reading process. It was assumed that visual discrimination, memory, rule abstraction, language, and serial ordering are prerequisite to reading success. It was further assumed that visual discrimination and memory are most significant at the initial stages of reading and that rule abstraction and language are important to continued progress in reading. It was hypothesized that poor deaf readers do not progress beyond the preliminary levels as a result of deficiencies in visual discrimination and memory and that other deaf readers fail to progress beyond the third grade reading level as a result of deficiencies in using linguistic rules. A group of poor deaf readers and good deaf readers were administered a battery of tests measuring the hypothesized factors. Factor analyses of the data indicated the following:

1. Poor readers are deficient in lower-order visual discrimination and memory abilities; however, there are higher-order visual discrimination skills that are important to success for the good readers.

2. Higher-order rule abstraction skills are important to continued progress in reading for the relatively successful readers; however, lower-order rule abstraction is important to successful visual discrimination at initial levels of reading for the poor reader as well.

3. Successful rule abstraction behavior is significant at all levels of reading--letter recognition, word recognition, sentence and paragraph comprehension.

4. Visual discrimination of a higher-order, viz., visual search and sequencing, is significant to the advanced reader for the processing of higher-level printed text.

The results of the investigation lead to the following implications:

1. The importance of rule abstraction at all levels of the reading process requires that the curriculum provide greater opportunity for the child to generate and test his own hypotheses and to develop rule hierarchies that aid him in transactions with his environment.

2. Visual discrimination activities in current use at pre-reading levels and at higher reading levels must be re-evaluated on the basis of new information from research in perceptual psychology.

3. Further information must be obtained about the syntactic structures of language-in-print that are peculiar obstacles to progress beyond intermediate levels of reading.

CHAPTER I

INTRODUCTION

Problem

The child who is retarded in reading confronts educators with their most serious and most frustrating problem. The child who does not read must necessarily achieve at a depressed level in other school subjects. The reading retardation thus intrudes upon all areas of learning, compounding its importance.

While reading is a prerequisite to the academic success of the normal child, it is even more critical for the deaf child, for whom printed communication is the most consistent and clear source of information. Other forms of communication, whether gestural or oral, are open to a high level of distortion through ambiguity, confusion, and misinterpretation. Thus, the deaf child is doubly penalized if he does not progress in reading; his knowledge of the world in general suffers as well as the more circumscribed work he does in school.

It is not surprising, then, that educators of the deaf have as deep an interest in the investigation of reading as do educators in general. The fact that only a minority of deaf children progress beyond a third grade reading level has been of increasing concern to their teachers. Along with their colleagues in general education, these teachers are becoming increasingly aware that present methods of teaching and remediation are not solving the problem. It is obvious that innovation must be introduced into an area that has been lacking in it.

Whether the reading retardation is the result of the poverty of experience on the part of the child or the teacher is totally irrelevant to the interested layman as well; he has become weary awaiting the solution of the problem by professional educators. Similarly, workers in education of the deaf are dismayed with the complacency of those describing the inevitability of the "third grade plateau." Of far greater value would be the specific description of deficiencies of children who do not progress. Language deficiencies of the deaf were once defined in terms of "omissions, additions, and substitutions"; today, research workers describe such errors more precisely in the productive terms of transformational grammar. We who work in reading education must seek to describe as precisely the child's deficiency in this skill. We must begin a thorough investigation of reading processes in order to define the contributing factors that determine the level of success in reading for deaf children.

Indeed, the reading process itself, apart from methods and teaching, has been the subject of little rigorous investigation. It is amazing to those outside the field of education that so crucial a skill should be attended by so primitive a level of understanding of its nature. Although there have been many studies of reading, the greatest number has been directed towards a partisan attempt to defend particular methods or materials. Until recently, little attention has been given to the study of the psychological processes involved in reading. Within the last few years, however, several research workers have made attempts to define underlying factors.

Goins (1958) introduced the use of correlational analysis in the effort to describe visual perceptual factors involved in reading. She found two components related to reading achievement in first grade children--perceptual speed and strength of closure. Goetzinger (1960) compared auditory discrimination as well as visual perception in good and poor readers. He also found that figure-ground relationships and perceptual speed were significant to success in reading. Smith and Corrigan (1959) went further in ascribing reading difficulties to physiological brain processes. They used measures of perception and cognition to compare profiles of scores of poor and good readers. They described perceptual deficiencies in terms of chemical imbalance at the point of synapse. Spearman's (1963) factor analysis of their data isolated factors of perceptual speed, perceptual memory and perceptual closure and an intellectual factor. Doehring (1966), in an unpublished study, found sequential processing to be a factor in his comparison of good and poor readers.

Gibson (1965), and Hochberg (1965), both experimental psychologists working in the area of perception, have become interested in reading as a special problem in perception. In an attempt to bring some order to the description of reading, Gibson assumes that the process proceeds from the initial perceptual discrimination of the grapheme, to the learning of the grapheme-phoneme correspondence, through the building up of sequences of the more complex units of words and sentences. Hochberg, defining the skill even more precisely, hypothesized two processes of importance to success, "peripheral search guidance" and "cognitive search guidance," both of which involve the reader in processing "chunks" of reading matter. The first process is basic to the second; it includes such activity as the initial letter processing of words. The second is a more complex activity in which the reader samples larger chunks of text, and demands knowledge of the language.

Most research workers in the education of the deaf have not attempted to study the reading process in depth. Some investigators have isolated specific abilities such as visual perception (Blair, 1957) and sentence structure (Woodward,1963), that were related to success in reading. Others, such as Farrant (1964) and Fuller (1959), while not investigating reading specifically, have begun to study the underlying factors of academic performance in the deaf using correlational techniques. While these results are of interest, we must go a step further if we wish to obtain a systematic body of knowledge about the reading process. We must describe the process of reading in terms of all the underlying abilities important to the deaf child's success. We must obtain more precise information about the skills upon which reading mastery is dependent. This information is absolutely necessary if there is to be any real improvement in instruction and remediation. Research workers must begin to consider reading as a set of hypothesized skills rather than as one global ability. It would then become possible to test their hypotheses by comparing the level of performance of poor and successful readers on these skills.

The investigation under consideration is an attempt to pursue this course. From previous research with both hearing and deaf groups, it seemed reasonable to hypothesize the involvement of at least two factors in the mastery of reading--visual discrimination and memory. The discrimination of letter forms and of the more complex word and sentence units is dependent upon visual perceptual abilities. Memory processing of these units of varying lengths is of equal importance. These two factors are believed to be basic to initial success in reading. They must be functioning in order for the child to learn even the simplest words at the primary levels.

Visual discrimination and memory continue to be important even with the increasing complexity of language in the printed text; however, with this complex language, other factors become critical. The reader at this level must understand higher order rules of the structure of his spoken language before he can be expected to succeed in understanding its transcription into printed text. It is assumed here that the model of generative grammar is the most constructive approach to the study of language; we assume further that language is learned through the abstraction of rules. Successful rule abstraction behavior becomes then a prerequisite for the mastery of language and reading.

The assumption has been made by psycholinguists (Smith and Miller, 1966) that rule abstraction is a basic process that is applied with all data. If such a fundamental process does exist, then it is reasonable to assume that, before the meaning and uses of verbal symbols are understood by the child, the process is used in the organization of non-verbal elements. That is, it is first used at a pre-verbal level only. Since the most crucial aspect of the rule abstracting process is hypothesis generation, it is absolutely necessary that the child be afforded the opportunity to test his hypotheses. Such opportunities exist for the deaf child in the development of rules about objects; his extremely limited exposure to language permits only meager opportunity for hypothesis testing in the development of linguistic rules. In an investigation of the deaf child's reading abilities, it becomes critical to determine whether his basic ability to abstract rules is lacking or his opportunity to work with rules of his language. If visual perception and memory are intact but basic rule abstraction abilities are disturbed, we might expect initial success in early reading where associative processes may suffice; as the words and sentences increase in length and the phonetic rules of English become more complex, continued success would be precluded. Where basic rule abstraction processes are functioning but opportunities for the development of linguistic rules have been few, it is possible for the child to progress beyond the early reading levels. The increasing complexity of sentence structure, however, will not permit him to advance to the highest reading levels. When he has had sufficient opportunity to discern and learn syntactic elements of English, only then may we expect him to attain such reading levels.

Critical to these factors, whether of lower or higher order, is sequential processing. The ability to process elements, whether verbal or non-verbal, in their proper order, is fundamental to learning and obviously crucial at all reading levels. While more sophisticated development of the process is required for activities differing in complexity, it is assumed to be the same fundamental process at all behavioral levels (Lashley, 1961). In early reading, the ability to discriminate cat from hat is based not only upon the perception of differences in the letters, but also upon the perception of the letters in their proper order. In addition, the words so discriminated must be remembered for later recognition, so that the process of serial ordering interacts with processes of visual discrimination and memory. The more advanced reader obviously has the skill needed to successfully process simple units; he could not succeed beyond the most primitive levels without it. A more complex development of the skill of ordering is necessary to continued progress, however; as the printed text becomes more advanced, comprehension of larger chunks of text is accomplished only through the highly skilled process of structuring words into grammatically sensible syntax. Obviously, the advanced reader has been successfully ordering the elements of reading, ranging from the letter series in words to the reversal of subjunctive clauses. The poor reader may still have difficulty at the most elementary level of letter reversal, and even the intermediate reader may be blocked at word order and sentence structure. Thus, the ability of the child to order elements at varying levels of complexity is still another factor determining his success in reading.

In summary, it is assumed that reading is dependent upon subordinate processes, among which are included visual discrimination, memory, rule abstraction, linguistic knowledge, and serial ordering. It is further assumed that these processes are hierarchical. It is expected that poor deaf readers, those who fail to progress beyond the lowest levels, will be hindered by impairment in visual discrimination and memory. These two primary abilities will discriminate within the group of poor deaf readers; i.e., within the range of these readers, differences in the two abilities will determine status in the group. There will be less variance in rule abstraction and linguistic knowledge, since the group will be more uniformly depressed on these functions. In addition, any variance on the higher order factors will probably be a function of the variance on the lower order factors, because of their hierarchical nature.

The deaf readers who progress to intermediate and advanced levels will not be expected to vary greatly on the lower order factors. Their achievement beyond primary reading levels indicates that they have relatively uniform attainment of the visual discrimination and memory skills necessary to such progress. It is expected that this group will reflect varying stages of proficiency in the higher order processes of rule abstraction and language; i.e., status within the group of successful readers will be determined by variation within these abilities. In addition, serial ordering ability will differentiate both groups of readers, good and poor. Status within the poor reading group will be determined by success at the level of perception of single symbol sequences; within the group of good readers, status will be determined by the ability to order grammatical rules of the language.

Thus, the present investigation was undertaken to provide a more precise description of the performance of poor and good deaf readers. Such precision was believed necessary from both a theoretical and a practical viewpoint. Theoretically, to provide systematic information about the reading process; practically, to determine predictors of reading success and to define specific skills for remediation.

CHAPTER II

METHODS

Research Design

Table 1 summarizes the design of the study.

The independent variable. After evaluation of several instruments, it was decided to use the Metropolitan Reading Achievement Test as the measure of the independent variable, because it was considered the most well-structured of those available. Three different levels of the test were administered to children of the following ages: Upper Primary, Form C. to 9-and 10-year-olds; Elementary, Form B, to 11- and 12-year-olds; Intermediate, Form BM to 13- and 14-year-olds. Children from four schools participated in the project - St. Mary's School, Buffalo, New York; Clarke School, Northampton, Massachusetts; Lexington School, New York, New York; and Pennsylvania School, Philadelphia, Pennsylvania. In order to insure optimal effort of each child, and since only raw scores were to be used in the analyses, the instructions were modified. These modifications included the simplification of wording appropriate to both oral and manual communication; visual aids for initial instructions, and separate practice pages containing an increased number of sample items. The instructions were communicated in the mode appropriate to the school. The raw scores obtained were subjected to tests of the differences between the means before the groups were combined. The means of only two schools did not differ, so that these alone could be combined for the major analyses. Nevertheless, it was decided to administer the test battery measuring the factors to the children in all four schools in order to provide school personnel with the comprehensive data available from these tests for use in their programs of remediation, as well as to obtain data for comparison with the combined schools.

In order to provide the most effective tests of the hypotheses, careful consideration was given to the dichotomization of the two groups, viz., the "poor" deaf readers and the "good" deaf readers. The reading range of most groups of deaf children is unusually restricted; the ambiguity of results of similar studies are a direct reflection of the failure to obtain differentiated groups because of this restriction. To obtain optimum differentiation between groups, only those subjects were used who fell at the extremes of the distribution of reading scores. The reading scores were normalized, using T-Scores for each age group. The normalized distributions were computed separately for each school, so that their poor and good readers would be easily identified for school

TABLE 1

Design for the Study of Reading Achievement in Deaf Children

	Measuring Instruments	Statistics	Results
Independent Variable	Metropolitan Reading Achievement Tests - 3 Levels Primary (9-10 yrs) Elementary (11-12 yrs) Intermediate (13-14 yrs)	1. Test of mean scores of subjects in participating schools. 2. Normalization of scores at each of 3 age levels for each of 4 schools.	1. Use of T-score to dichotomize children in each school into groups of good and poor readers. 2. Combining of good and poor readers in each school into one large group of good readers and one large group of poor readers for statistical analyses of the dependent variable.
Dependent Variable	Test Battery including several measures of each underlying factor.	1. Tests of means of poor and good readers. 2. Correlations of tests in battery separately for poor and good readers. 3. Factor analyses separately for good and poor readers. 4. Multiple correlations for each group.	1. Comparisons of test performance by good and poor readers. 2. Comparisons of factor loadings of test scores of good and poor readers. 3. Isolation of predictors of reading achievement.

personnel for remediation purposes. The poor readers were all those falling at T-Scores of 45 and below; the good readers were those falling at T-scores of 55 and above. The good and poor readers of all ages from the Lexington and Clarke Schools were combined into two large groups. Good readers and poor readers of all ages from the Pennsylvania School were combined into two groups, as were those of St. Mary's School. Thus, the initial analyses provided six groups for the final study:

1. two large groups, 39 good readers and 46 poor readers, aged 9 through 14, the combined groups from the Lexington and Clarke Schools;

2. two groups, 13 good readers and 12 poor readers, aged 9 through 14, from the Pennsylvania School; and

3. two groups, 13 good readers and 21 poor readers, aged 9 through 14, from St. Mary's School.

The dependent variables. Careful search was made for the most productive measures of the underlying factors. After final evaluation, those tests were selected that were most appropriate measures of the factors, as well as most appropriate for administration to a deaf population. In several instances, neither criterion was met by available tests and it became necessary to devise new tests.

The test battery. In order to obtain as complete a description as possible of the child's performance on the hypothesized factors, several instruments were selected to measure each of them.

1. Visual Discrimination

   a) Bender-Gestalt Visual Perception Test; Memory for Design Test.

      These are tests of visual-motor ability, providing information about the visual perception of meaningless symbols without fine detail. Both tests have been found to discriminate between poor and good readers (DeHirsch, 1966; Koppitz, 1959).

   b) Goodenough-Harris Draw-A-Man Test.

      This is a test providing information about the child's perception of bodily parts, their form and location. Koppitz (1959) found that human figure drawings by children predicted their reading level.

c) Thurstone Identical Forms Test.

A test requiring the discrimination of differences in fine detail. This test has a high loading on the perceptual speed factor in the Spearman study of reading (1963).

d) Hidden Figures Test.

This test requires the discrimination of a form embedded in a distracting background. It is a measure of the ability to suppress irrelevant detail while attempting to discover the figure, which Santostefano and Rutledge (1965) found significant in discriminating reading success.

e) Gibson Transformations.

A test designed by Eleanor Gibson, incorporating letter-like symbols. Each of 12 symbols is subjected to transformations similar to those of letters in print, e.g., rotation, change in angle, change of curves to lines. The child must locate the standard symbol from a group of transformed symbols. The test is a sophisticated measure of letter discrimination without using printed materials.

f) Doehring Sequential Forms.

A test requiring the discrimination of forms in sequences. The child must locate the standard sequence from an assortment of sequences. The test provides a measure of the child's ability to discriminate differences in the form of a single symbol and of a group of single symbols in a recurring sequence. Doehring (1966) found visual sequencing significant in differentiating poor and good readers.

g) Gibson Letter Combinations.

A test requiring the child to discriminate letters in meaningful, meaningless but pronounceable, and unpronounceable sequences, e.g., can, nac, nca. The task provides information about the child's ability to discriminate single letters and letters in recurring sequences, varying the aid available through experience with language. It was included as a measure of visual sequencing at the higher level of the printed symbol.

2. Memory

The tests used are measures of short-term memory. Although it is long-term memory that is important to reading skill, recent research (Neisser, 1967) indicates that the processes active in short-term memory are antecedent to long-term memory encoding. A test of long-term memory would provide us with the most valuable information for our purposes; however, it was not feasible to use such measures with the large number of subjects in the study within the time allotted. The assumption was made, therefore, that measures of short-term memory would provide us with information about the child's long-term memory ability. Such tests have been found consistently to discriminate differences in reading ability (Sawyer, 1965; Blair, 1957).

a) Digit Span Forward; Digit Span Backward.

These tests present the child with a series of single digits printed on cards. He is required to reproduce the series exactly as shown in the Digit Span Forward, and to reverse the order in the Digit Span Backward. Significant differences in this test discriminated between levels of reading success (Sawyer, 1965).

b) Associative Clustering - Memory Aspect.

This test uses Bousfield's clustering technique (1958), in which a series of words is presented on cards, one at a time. The child is required to write those words he remembers. Randomly placed in the series are exemplars of a specific concept; e.g., fruits, animals. This test was included as a measure of memory for the printed word.

3. Rule Abstraction

All measures of rule abstraction behavior selected for the battery are typical categorization tasks. Exemplars are presented and the child must use rule abstraction behavior to discover the category to which they belong. It was decided to test such behavior with non-verbal and verbal stimuli because the categorization of printed "labels" might require different abilities than those needed to categorize two dimensional pictures. For each of the three non-verbal tests, a verbal analogue was devised by project personnel and consultants. Although an attempt was made to use words at Level A of the

Thorndike-Lorge Word Count (1944), it was expected that the verbal presentation would be less reliable for the group of poor readers than for the group of good readers. Thus, valid comparisons of rule behavior with non-verbal and verbal items could be made for the good readers only. It was hypothesized that, within the distribution of good readers, there would be relatively clear rule abstraction factors. Comparisons of rule behavior on verbal and non-verbal tests within the range of good readers should provide valuable information.

Tests with different types of response modes were used in order to obtain measures of the different approaches to rule abstraction. An oddity problem test, in which the child is presented with four stimuli, decides upon a rule that covers three, and rejects one as not following the rule; a similarities test, in which he discovers the rule underlying three stimuli and then applies it to items in a multiple choice; and an analogies test, in which he finds a rule connecting two stimuli and then finds an analogous rule for two other stimuli.

a) Picture Classification.

Items from the Thurstone Picture Oddity Test were selected that were appropriate for the purposes of the study. A Word Classification Test was devised similar in response mode to the Picture Classification Test.

b) Picture Similarities.

The Picture Similarities Test from the California Test of Mental Maturity was selected as the most satisfactory measure of this type of rule abstraction. A Word Similarities Test was devised as the verbal analogue.

c) Picture Analogies.

Fourteen of the items from the Picture Analogies Test of the California Test of Mental Maturity were selected for use in the study. A Verbal Analogies Test was constructed similar in format to the non-verbal test.

The child does not typically develop rules through the simultaneous presentation of instances; his rules are developed on the basis of discrete instances occurring over time. Most tests of rule abstraction, including those described above, measure rules developed on the basis of simultaneous presentation. It was decided to measure rule behavior on tasks more closely resembling the reality of sequential occurrence.

d) Picture Sequential Similarities; Verbal Sequential Similarities.

Both tests require the child to discover the rule underlying three stimuli, presented to his view one at a time. He then applies the rule to another item in a multiple choice. A further measure of this sequential presentation of a rule abstraction is the Clustering Score of the Associative Clustering Test, mentioned in the section on memory. This score is based upon the order in which the child writes the names remembered; i.e., the number of instances in which two or more exemplars of the concept are written consecutively. Bousfield interprets the score as an indication of categorization behavior (1958).

4. Linguistic Rule Behavior

a) Cooper Tests #2 and #4.

Two measures of the knowledge of syntactic structure, developed for use with a deaf population by Robert Cooper, were selected. In Cooper Test #2, the child must discover grammatical mistakes in printed sentences. In Cooper Test #4, the child must decide which of two pictures best fits a printed sentence.

b) Logical Thinking Test.

This is a test of the ability to use rules in the manipulation of events, commonly found in propositions of symbolic logic. This test and the two tests of linguistic knowledge depend heavily upon reading skill. Although an attempt was made to keep within the limits of Level A words on the Thorndike-Lorge List, these tests are designed to discriminate within the distribution of good readers only. Again, it was hypothesized that differences in the knowledge of linguistic rules would become important only in the range of good readers.

5. Sequential Processing

Among the tests selected to measure the preceding four factors have been included several that involve serial ordering. The Doehring Test, a measure of visual discrimination, requires the child to recognize a specific pattern of figures. The Digit Span Tests, tests of short-term memory, require the child to recall digits in the order presented. The Gibson Letter Combinations requires the same ordered response, using letters as the stimuli. The categorization tests all presume a serial processing of each stimulus as hypotheses are tested in developing the rule; however, the sequential forms of the categorization tests were designed deliberately to require the child to process each stimulus in order. He is required to encode one exemplar at a time, without constant scanning of all three, as is permitted in the simultaneous presentation. The Cooper #4 Test requires the child to consider minor differences in syntactic order when selecting appropriate pictures. The Logical Thinking Test is at the very highest level, requiring the serial processing of propositions to reach a conclusion.

Analyses

For the combined groups; i.e., the groups of good and poor readers formed by combining the children from the Lexington and Clarke Schools; the following statistics were computed separately for each group:

1. means, standard deviations for all 23 tests and tests of differences between means of good and poor readers;
2. correlations of all tests;
3. multiple correlations of test scores with reading scores;
4. factor analyses;
5. reliabilities of new tests.

All the above statistics, except the factor analyses and reliabilities, were computed for each of the two schools not included in the major analyses. Means, standard deviations and tests of the differences were computed separately for each of the combined schools, to be used by school personnel for remediation purposes.

CHAPTER III

RESULTS AND FINDINGS

Descriptive Statistics

The means and standard deviations for poor and good readers in each of the four participating schools, with significance levels of the differences between the means, are presented in Tables 2 through 5.

Only 22 tests are reported for the Pennsylvania and St. Mary's Schools because they were not administered the Logical Thinking Test.

For good and poor readers from all schools the differences between the test means were found in the Digit Span Forward, Cooper #2 and #4, Picture Analogies, Word Similarities, Verbal Analogies, and Verbal Sequential Similarities. Mean differences were less evident in the tests of visual perception. Differences in visual perception tests for the two groups from the Clarke School were found in the Doehring Visual Sequencing Test; in the Lexington School groups, differences occurred in Hidden Figures and Memory-for-Designs; the Pennsylvania groups differed on Gibson Letter Combinations; and the St. Mary's School groups differed on the Draw-a-Man and the Bender-Gestalt Test.

The means, standard deviations and t-tests for the two combined school groups are found in Table 6. Differences between the larger groups are found in 18 of the 23 tests; greater differentiation is to be expected here as a result of the larger number of subjects and the wider range of their reading achievement.

Correlation Matrices

Correlation matrices were run for all schools, including biographical items and tests, 27-28 variables in all. The Lexington and Clarke School groups were combined for the computation of correlations, since these provided the data for the factor analyses. The factor analyses will be considered in a later section.

The correlation matrices for St. Mary's School and the Pennsylvania School are not presented here in toto, since the small number of subjects in each group permits us to consider only the highest correlations as meaningful. Correlation coefficients of .65 or greater were considered acceptable for evaluation; nevertheless, the small number of subjects in each group requires that great caution be exercised in generalizations about the results. Tables 7 through 10 present the clusters of tests that correlated

Means, Standard Deviations and Significance Levels of Test Scores of Subjects from the Clarke School for the Deaf

Test	Poor Readers (N=28)		Good Readers (N=22)		t
	Mean	Standard Deviation	Mean	Standard Deviation	
Draw-A-Man	93.67	15.19	97.95	11.90	
Bender-Gestalt	2.25	1.84	2.09	1.57	
Hidden Figures	69.07	5.59	71.82	9.44	
Thurstone Identical Forms	93.86	16.46	100.18	17.80	
Gibson Transformations	65.89	11.03	68.04	4.47	
Gibson Letter Combination	13.00	2.16	13.54	1.30	
Doehring Test	54.68	2.16	55.86	1.12	.05
Digit Span Forward	24.39	12.75	38.82	13.54	.01
Digit Span Backward	44.21	14.64	52.59	9.96	.05
Memory for Design	.79	1.34	1.59	2.15	
Associative Clustering-Memory	9.86	3.06	11.50	1.84	.05
Associative Clustering-Clustering	2.57	1.32	2.91	1.57	
Cooper #2	13.79	3.53	18.86	2.08	.01
Cooper #4	12.84	2.05	14.34	1.19	.01
Picture Classification	9.46	1.64	11.36	1.99	.01
Picture Similarities	15.43	.84	15.77	.43	
Picture Analogies	10.04	2.90	12.09	1.27	.01
Picture Sequential Similarities	11.29	1.61	12.59	1.30	.01
Word Classification	5.75	2.35	9.36	2.34	.01
Word Similarities	8.43	2.87	11.50	1.34	.01
Verbal Analogies	9.50	2.33	12.96	1.79	.01
Verbal Sequential Similarities	7.96	2.13	10.77	1.31	.01
Logical Thinking	4.96	2.08	7.18	1.37	.01

TABLE 3

Means, Standard Deviations and Significance Levels of Test Scores of Subjects from the Lexington School for the Deaf

Test	Poor Readers (N=18)		Good Readers (N=17)		t
	Mean	Standard Deviation	Mean	Standard Deviation	
Draw-A-Man	93.58	14.67	93.29	13.17	
Bender-Gestalt	1.78	1.63	.94	1.09	
Hidden Figures	68.83	11.15	76.88	11.21	.05
Thurstone Identical Forms	101.33	26.80	114.76	14.72	
Gibson Transformations	66.50	6.04	69.24	3.82	
Gibson Letter Combination	12.89	2.06	14.24	.90	.05
Doehring Test	54.89	1.74	56.47	.87	.01
Digit Span Forward	33.61	13.17	54.18	13.14	.01
Digit Span Backward	45.17	13.16	57.59	18.11	.05
Memory for Designs	2.44	2.57	.76	.90	.05
Associative Clustering-Memory	10.72	2.95	11.47	1.66	
Associative Clustering-Clustering	2.61	1.42	3.82	1.67	.05
Cooper #2	14.78	2.39	18.65	2.74	.01
Cooper #4	11.97	2.95	14.29	1.57	.01
Picture Classification	10.33	1.97	11.29	1.45	
Picture Similarities	15.11	1.41	15.53	.62	
Picture Analogies	10.39	2.59	12.18	1.47	.05
Picture Sequential Similarities	12.22	1.59	12.47	1.18	
Word Classification	7.44	2.53	9.24	1.72	.05
Word Similarities	9.28	2.78	11.65	1.62	.01
Verbal Analogies	10.28	3.61	13.06	1.64	.01
Verbal Sequential Similarities	8.83	2.46	10.59	1.84	.05
Logical Thinking	5.56	2.06	7.35	1.00	.01

TABLE 4

Means, Standard Deviations and Significance Levels of Test Scores of Subjects from the Pennsylvania School for the Deaf

Test*	Poor Readers (N=12)		Good Readers (N=13)		t
	Mean	Standard Deviation	Mean	Standard Deviation	
Draw-A-Man	95.79	7.98	101.62	12.43	
Bender-Gestalt	3.25	3.02	2.69	1.65	
Hidden Figures	69.92	11.16	73.77	12.12	
Thurstone Identical Forms	102.42	15.46	108.69	19.07	
Gibson Transformations	62.25	5.05	59.00	13.29	
Gibson Letter Combination	12.83	2.08	14.38	.96	.05
Doehring Test	54.25	3.14	54.85	1.99	
Digit Span Forward	34.08	12.02	46.00	14.92	.05
Digit Span Backward	36.00	13.63	53.00	14.51	.01
Memory for Design	2.83	3.56	2.31	2.25	
Associative Clustering-Memory	8.83	3.24	11.31	1.32	.05
Associative Clustering-Clustering	2.25	1.86	3.38	1.19	
Cooper #2	12.42	3.58	17.08	4.13	.01
Cooper #4	11.04	2.58	14.58	.64	.01
Picture Classification	9.83	2.37	10.23	1.30	
Picture Similarities	13.83	3.86	15.54	.66	
Picture Analogies	8.33	3.31	11.31	1.93	.05
Picture Sequential Similarities	11.08	1.78	12.85	1.07	.01
Word Classification	6.17	1.80	7.23	1.54	
Word Similarities	7.00	2.59	10.31	1.75	.01
Verbal Analogies	8.00	2.45	11.15	1.62	.01
Verbal Sequential Similarities	8.33	2.42	10.31	2.14	.05

*Logical Thinking Test not administered.

TABLE 5

Means, Standard Deviations and Significance Levels of Test Scores of Subjects from St. Mary's School for the Deaf

Test*	Poor Readers (N=21)		Good Readers (N=13)		t
	Mean	Standard Deviation	Mean	Standard Deviation	
Draw-A-Man	85.45	9.81	93.19	8.76	.05
Bender-Gestalt	3.29	1.85	2.00	1.63	.05
Hidden Figures	65.90	8.07	71.15	11.00	
Thurstone Identical Forms	98.90	22.80	106.69	13.49	
Gibson Transformations	62.19	6.89	64.69	5.98	
Gibson Letter Combination	12.57	2.48	13.31	1.70	
Doehring Test	54.19	2.54	50.31	15.20	
Digit Span Forward	23.24	12.11	38.31	19.48	.01
Digit Span Backward	36.81	16.88	54.54	19.58	.01
Memory for Design	4.33	4.30	1.92	1.94	
Associative Clustering-Memory	8.71	2.59	10.85	2.44	.05
Associative Clustering-Clustering	1.86	1.35	3.31	1.11	.01
Cooper #2	13.29	2.26	16.00	4.34	.05
Cooper #4	10.36	2.39	13.38	2.27	.01
Picture Classification	9.10	2.17	9.77	2.56	
Picture Similarities	14.48	2.04	15.31	1.32	
Picture Analogies	9.43	2.11	11.23	2.13	.05
Picture Sequential Similarities	10.38	1.77	12.15	1.28	.01
Word Classification	4.62	2.04	7.54	2.18	.01
Word Similarities	6.52	2.66	10.31	2.69	.01
Verbal Analogies	7.43	2.48	10.31	2.53	.01
Verbal Sequential Similarities	6.29	2.26	8.77	2.20	.01

* Logical Thinking Test not administered.

Means, Standard Deviations and Significance Levels of Test Scores for Combined Groups

Test	Poor Readers (N=46)		Good Readers (N=39)		t
	Mean	Standard Deviation	Mean	Standard Deviation	
Draw-A-Man	93.63	14.82	95.92	12.52	
Bender-Gestalt	2.06	1.76	1.59	1.48	
Hidden Figures	68.98	8.11	74.03	10.42	.05
Thurstone Identical Forms	96.78	21.16	106.54	17.89	.05
Gibson Transformations	66.13	9.32	68.56	4.18	
Gibson Letter Combination	12.96	2.10	13.85	1.18	.05
Doehring Test	54.76	1.99	56.13	1.06	.01
Digit Span Forward	28.00	13.56	45.51	15.28	.01
Digit Span Backward	44.59	13.94	54.77	14.11	.01
Memory for Design	1.44	2.06	1.23	1.75	
Associative Clustering-Memory	10.20	3.02	11.49	1.74	.05
Associative Clustering-Clustering	2.59	1.34	3.31	1.66	.05
Cooper #2	14.17	3.14	18.77	2.36	.01
Cooper #4	12.50	2.45	14.32	1.35	.01
Picture Classification	9.80	1.81	11.33	1.75	.01
Picture Similarities	15.30	1.09	15.67	.53	
Picture Analogies	10.17	2.76	12.13	1.34	.01
Picture Sequential Similarities	11.65	1.65	12.54	1.23	.01
Word Classification	6.41	2.54	9.31	2.07	.01
Word Similarities	8.76	2.84	11.56	1.45	.01
Verbal Analogies	9.80	2.89	13.00	1.70	.01
Verbal Sequential Similarities	8.30	2.28	10.69	1.54	.01
Logical Thinking	5.20	2.07	7.26	1.21	.01

TABLE 7

Test Clusters with Correlation Coefficients Over .65:
Pennsylvania School-Poor Readers (N=12)

Bender-Gestalt Gibson Trans. (.82) V. Seq. Sim. (.66)	Hidden Figures Thurs. Id. (.81) P. Seq. Sim. (.67) Word Class. (.78)	Thurstone Id. Forms Hidden Figs. (.81) Gibson Lett. (.72) Mem. F. D. (.79)	Gibson Trans. Bender-Gest. (.82) Digit S. F. (.66)
Gibson Letter Thurs. Id. (.72) Word Sim. (.71)	Doehring Test Digit S.B. (.78) Cooper #2 (.84)	Digit Span For. Gibson Trans. (.66)	Digit Span Back. Doehr. Tst. (.78) Asso. Cl.-Cl. (.69)
Memory for Design Thurs. Id. (.79) Cooper #4 (.92) Pict. Sim. (.75)	Asso. Clust.-Mem. Asso. Cl.-Cl. (.71)	Asso. Clust.-Clust. Digit S.B. (.69) Asso. Cl.-Mem. (.71)	Cooper #2 Doehr. Tst. (.84)
Cooper #4 Mem. F. D. (.92) Pict. Sim. (.68)	Pict. Class. P. Seq. Sim. (.69)	Pict. Sim. Mem. F. D. (.75) Cooper #4 (.68)	Pict. Anal. Cooper #4 (.66)
Pict. Seq. Sim. Pict. Class. (.69) Hidden Figs. (.67) Read. T Sc. (.66)	Word Class. Hidden Figs. (.78)	Word Sim. Gibson Lett. (.71) Verb. Anal. (.60) V. Seq. Sim. (.82)	Verb. Seq. Sim. Word Sim. (.82) Bender-Gest. (.66)

TABLE 8

Test Clusters with Correlation Coefficients Over .65:
Pennsylvania School-Good Readers (N=13)

<table>
<tr>
<td><u>Draw-A-Man</u>

Pict.Class. (.71)
Verb.Anal. (.71)</td>
<td><u>Bender-Gestalt</u>

Doehring Tst. (.72)
Mem.for Des. (.68)</td>
<td><u>Hidden Figures</u>

Doehring Tst. (.71)</td>
</tr>
<tr>
<td><u>Thurstone Id. Forms</u>

Verb.Anal. (.66)</td>
<td><u>Gibson Letter</u>

Doehring Tst. (.82)
Cooper #2 (.79)</td>
<td><u>Doehring Test</u>

Bender-Gestalt (.72)
Hidden Fig. (.71)
Gibson Lett. (.82)
Pict.Class. (.72)</td>
</tr>
<tr>
<td><u>Digit Span Forward</u>

Assoc.Cl.-Mem. (.72)
Pict.Class. (.70)</td>
<td><u>Memory for Design</u>

Bender-Gestalt (.68)</td>
<td><u>Asso.Clust.-Mem.</u>

Digit S.F. (.72)
Asso.Cl.-Cl. (.66)</td>
</tr>
<tr>
<td><u>Asso. Clust.-Clust.</u>

Asso.Cl.-Mem. (.66)</td>
<td><u>Cooper #2</u>

Gibson Lett. (.79)
Pict.Seq. (.66)
Verb.Seq.Sim. (.66)</td>
<td><u>Cooper #4</u>

Pict.Anal. (.72)
Verb.Seq.Sim. (.68)</td>
</tr>
<tr>
<td><u>Picture Class.</u>

Draw-A-Man (.71)
Doehring Tst. (.72)
Digit S.F. (.70)
Verb.Anal. (.77)</td>
<td><u>Picture Analogies</u>

Cooper #4 (.72)</td>
<td><u>Picture Seq.Sim.</u>

Cooper #2 (.66)</td>
</tr>
<tr>
<td><u>Word Classification</u>

Verb.Anal. (.65)</td>
<td><u>Verbal Analogies</u>

Draw-A-Man (.71)
Thurs.Id.F. (.66)
Pict.Class. (.77)
Word Class. (.65)</td>
<td><u>Verbal Seq.Sim.</u>

Cooper #2 (.66)
Cooper #4 (.68)</td>
</tr>
</table>

TABLE 9

Test Clusters with Correlation Coefficients Over .65:
St. Mary's School-Poor Readers (N=21)

Draw-A-Man Memory for Design (.74) Picture Analogies (.66)	Thurstone Identical Forms Picture Similarities (.69)	Gibson Transformations Verbal Analogies (.74)
Digit Span Forward Digit Span Backward (.76)	Memory for Design Draw-A-Man (.74)	Picture Classification Word Similarities (.67)

TABLE 10

Test Clusters with Correlation Coefficients Over .65:
St. Mary's School-Good Readers (N=13)

Draw-A-Man Read. T Sc. (.77) Asso. Cl.-Mem (.69)	**Hidden Figures** Thurs. Id. (.72) Gibson Trans. (.76) Digit S.F. (.67) Digit S.B. (.67) Mem. F.D. (.71) Asso. Cl.-Mem. (.66) Pict. Anal. (.65)	**Thurstone Id. Forms** Hidden Figs. (.72) Digit S.F. (.76) Digit S.B. (.66) Asso. Cl.-Mem. (.69) Cooper #2 (.77) Pict. Anal. (.72) V. Seq. Sim. (.64)	**Gibson Trans.** Hidden Figs. (.76) Asso. Cl.-Mem. (.81)
Gibson Letter Digit S.F. (.72)	**Digit Span For.** Hidden Figs. (.67) Thurs. Id. (.66) Gibson Lett. (.72) Cooper #2 (.82) Word Class. (.67) Word. Sim. (.65) Verb. Anal. (.65)	**Digit Span Back.** Hidden Figs. (.67) Thurs. Id. (.66) Digit S.F. (.65) Cooper #2 (.68)	**Memory for Design** Hidden Figs. (.71)
Asso. Clust.-Mem. Draw-A-Man (.69) Hidden Figs. (.66) Thurs. Id. (.69) Gibson Trans. (.80) Word Class. (.67)	**Asso. Clust.-Clust.** Word. Sim. (.80)	**Cooper #2** Thurs. Id. (.77) Digit S.F. (.82) Digit S.B. (.68) Cooper #4 (.72) Pict. Class. (.78) Pict. Anal. (.70) Word Sim. (.78) Verb. Anal. (.67)	**Cooper #4** Cooper #2 (.72) Word Class. (.84) Word Sim. (.72) Verb. Anal. (.81)

(continued)

(continued TABLE 10)

<u>Pict. Class.</u> Cooper #2 (.78) Word Sim. (.69)	<u>Pict. Sim.</u> Pict. Anal. (.72)	<u>Pict. Anal.</u> Pict. Sim. (.72) Hidden Figs. (.65) Thurs. Id. (.72) Cooper #2 (.70)	<u>Word. Class.</u> Digit S.F. (.67) Asso. Cl.-Mem (.67) Word Sim. (.71)
<u>Word Sim.</u> Digit S.F. (.65) Asso. Cl.-Cl. (.80) Cooper #2 (.78) Cooper #4 (.72) Pict. Class. (.69) Word Class. (.71) V. Seq. Sim. (.77)	<u>Verb. Anal.</u> Digit S.F. (.65) Cooper #2 (.67) Cooper #4 (.81) V. Seq. Sim. (.69)	<u>Verb. Seq. Sim.</u> Word Sim. (.77) Verb. Anal. (.69)	

at .65 and higher. Inspection of the tables indicates that, not only do the scores appear to differ in good and poor readers from each school, but they also appear to differ among all four groups.

Tables 7 and 8 report the correlation clusters of the groups from the Pennsylvania School. For the poor readers, a visual perception cluster is apparent in the tests correlating with the Thurstone Identical Forms. The Memory-for-Designs cluster is interesting in that both the Cooper #4 and Picture Similarities require intensive visual search of pictured stimuli for correct response. The Word Similarities cluster is a clearly verbal relationship.

For the good readers from the Pennsylvania School, we find the Doehring Test cluster presents a relatively clear visual perception relationship. Again, intensive visual search aspects of the Picture Classification Test may be involved in its correlation with the Doehring Test. The Cooper #4 cluster, while strongly verbal, includes a sequential factor in each of its tests. The Picture Classification Test, a measure of rule abstraction, again correlates highly with visual perception tests. The Draw-a-Man, Doehring, and Digit Span Tests all require a more complex processing of visual input than required on the Bender-Gestalt or Memory-for-Designs; it may be this higher order processing that relates to the Picture Classification.

Tables 9 and 10 present the clusters of the poor and good readers of St. Mary's School. The poor readers are apparently a highly variable group presenting few examples of correlated scores. The test scores of the good readers, on the other hand, are related in several instances. Of greatest interest are the Hidden Figures cluster, Associative Clustering--Memory cluster, and the Digit Span Forward cluster. The Hidden Figures Test correlates highly with other visual perception tests and memory tests as well. The ability to keep the figure in mind while searching for it is probably the variable involved here. The Associative Clustering--Memory Test is related to four visual perception tests; the letter discrimination aspect of the test may be involved in these correlations. The Digit Span Forward is correlated with tests of visual perception and language.

While the small size of the groups render these correlations not entirely reliable, certain relationships are indicated. Most interesting is the finding that tests of visual perception apparently relate at several levels, i.e., to other tests of visual perception and to more complex rule abstraction tests as well.

Factor Analyses

In Tables 11 and 12 are reported the factors isolated from the rotation of the correlation matrices for the two combined groups.

It was decided that those loadings of .50 and above would be considered in factor descriptions; Tables 13 and 14 present these factor loadings. It should be noted that the factor loadings differ in most cases in the two groups. Apparently, different abilities are being reflected in the performance of the poor and good readers on this battery of tests.

The factor loadings for the poor readers confront us with a most complex description of abilities. Factor One includes 6 rule abstraction tests and may be termed a rule abstraction factor, except for the fact that it includes three visual discrimination tests and a language test as well. Factor Four is more likely a visual perception factor; however, short-term memory is also involved, certainly in the Memory-for-Designs and Digit Span Forward, and probably in the Hidden Figures. Thus, it may be termed a visual memory factor. Factors Two and Five do not lend themselves to a blanket description. Factor Three seems to be determined by the Reading T-Score; the Bender-Gestalt, Gibson Transformations, and Word Similarities may be the tests most directly related (for this group) to the ability to discriminate letters and words in print.

For the good readers, Factor One can be termed a rule abstraction factor. Both the Gibson Transformations and the Associative Clustering--Memory involve rule generation. The manner in which the Gibson Transformation Test was administered permitted the most efficient response to be given if a rule were developed that pre-determined the point at which to begin the actual discrimination of detail; the Associative Clustering--Memory Score was dependent upon the efficiency with which concept names were organized and retrieved. Factor Two is apparently a visual perception and short-term memory factor; the loadings of the language tests here seem to be accounted for by the visual search necessary for response to their tasks. Thus, the factor seems to have isolated the visual search aspects of visual perception. Factor Five is apparently another visual perception factor. It would seem to be of a higher order since whatever visual perceptual processes are involved in the complex test of Logical Thinking must require visual search and sequencing skill. Factors Three and Four do not lend themselves to description.

TABLE 11

Rotated Factor Matrix for Poor Readers*

Tests	Factors .001	.002	.003	.004	.005	Communality
Picture Similarities	.8013	.0979	.1462	.0038	.1476-	.6948
Verbal Analogies	.7900	.2878	.2880	.1445	.1805	.8434
Picture Analogies	.7228	.1421	.0446	.0098	.1564	.5692
Gibson Letter Combination	.6463	.0723	.0707	.0711	.1807	.4656
Verbal Sequential Similarities	.6283	.0437-	.3768	.0151-	.1595	.5643
Picture Classification	.5961	.1631-	.2406	.2026	.1180	.4948
Cooper #4	.5341	.2000	.4580	.0382	.0081-	.5365
Doehring Test	.4544	.0443-	.1001	.3458	.1440	.3588
Cooper #2	.3760	.0248-	.3615	.1865-	.1897	.3434
Associative Clustering-Memory	.1831	.8689	.1932	.0277	.0503	.8292
Associative Clustering-Clustering	.0059	.7697	.0451	.1078-	.0008-	6061
Draw-A-Man	.0367	.6171-	.2040	.2590	.2055-	.5331
Age	.4946	.5761	.3643	.0807	.2074	.7588
Word Similarities	.5170	.2006	.5896	.0071	.2685	.7273
Gibson Transformations	.0809	.0028-	.5688	.2042	.0416-	.3735
Reading Score	.1763	.1749	.5377	.0839-	.1619	.3840
Bender Gestalt	.0804-	.1629	.5055-	.3911-	.1573-	.4662
Picture Sequential Similarities	.4282	.0384	.4940	.0584	.0087	.4324
Memory for Designs	.1955-	.1458	.1049	.5551-	.0299	.3795
Hidden Figures	.5177	.0199-	.0211	.5543	.2220	.6253
Sex	.0370-	.0512-	.2122	.4701	.2861-	.3519
Digit Span Backward	.2491	.1527	.2966	.4122	.2101	.3874
Socio Economic Level	.0637	.0269	.0255-	.3841-	.0504	.1555
Digit Span Forward	.2334	.0962	.4913	.0005-	.6490	.7263
Word Classification	.3184	.0196-	.4930	.0213	.6390	.7535
Logical Thinking	.2588	.2734	.2968	.1492	.5699	.5769
Thurstone Identical Forms	.3630	.2906	.0247	.3139	.4151	.4877
Hearing Loss	.0018	.0261	.0323-	.1071-	.4028	.1755

* Varimax Rotation

TABLE 12

Rotated Factor Matrix for Good Readers*

Tests	Factors .001	.002	.003	.004	.005	Communality
Verbal Analogies	.7477	.1652	.1003	.0392-	.2665	.6689
Verbal Similarities	.6302	.2448	.1328	.1773	.0677	.5108
Associative Clustering-Memory	.6268	.1397	.2158	.1274-	.0715	.4803
Gibson Transformations	.5429	.2376	.0992-	.1757-	.4503	.5947
Picture Analogies	.5369	.1164	.0769	.0380	.0382	.3106
Picture Classification	.5162	.0279	.2725-	.1609	.2067	.4101
Age	.5005	.2518	.1762	.0000-	.4804	.5758
Picture Sequential Similarities	.4083	.0900	.2208-	.1121-	.2606	.3041
Verbal Sequential Similarities	.3842	.0542-	.0485	.1873	.2120	.2330
Digit Span Backward	.0823	.7890	.0096	.0679	.1288	.6506
Hidden Figures	.1522	.7641	.1015	.0086-	.2539	.6819
Digit Span Forward	.0070-	.6032	.1508	.1004	.4475	.5970
Cooper #2	.3288	.4853	.0224-	.2447	.0124	.4041
Cooper #4	.2563	.4851	.0962	.1471	.0213	.3323
Gibson Letter Combination	.2312	.1520	.6437	.0624	.1058	.5059
Socio-Economic Level	.0570	.1132	.5353	.0672	.0652-	.3114
Hearing Level	.0008-	.0231-	.4984	.2395-	.2090	.3500
Sex	.0599	.2662	.3128-	.2617	.0005-	.2408
Draw-A-Man	.1309	.2535	.2874	.6065	.0854-	.5391
Picture Similarities	.0462-	.0494	.0278-	.5191	.0098	.2749
Word Classification	.3186	.0703	.1289-	.4833	.4149	.5287
Associative Clustering-Clustering	.2524	.3014	.0577	.3628-	.0079	.2896
Reading Score	.0803	.2444	.1682-	.3582	.0175	.2231
Doehring Test	.0586	.0737	.0533	.0864-	.7286	.5500
Logical Thinking	.3108	.0910	.0020-	.2741	.6732	.6332
Thurstone Identical Forms	.1829	.5199	.2931	.0831	.6285	.7916
Memory for Design	.1941-	.4103-	.3601	.0077	.5061-	.5918
Bender-Gestalt	.3416-	.1764-	.2960-	.2309	.4138-	.4599

*Varimax Rotation

TABLE 13

Factor Loadings of .50 and Over
Combined Group - Poor Readers

Factors					
1		2		3	
Hidden Figures	(.52)	Age	(.58)	Reading T-Score	(.54)
Gibson Letter	(.65)	Draw-A-Man	(-.62)	Bender-Gestalt	(.51)
Cooper #4	(.53)	Asso Cl.-Mem.	(.87)	Gib. Trans.	(.57)
Picture Class.	(.60)	Assoc Cl.-Cl.	(.77)	Word Similar.	(.59)
Picture Similar.	(.80)				
Picture Anal.	(.72)				
Word Similar.	(.52)				
Verbal Anal.	(.79)				
Verbal Seq. Similar	(.63)				
Doehr* (h=36)	(.45)				

* Test loading on only the one factor, with more than .30 of its common factor variance accounted for on this factor.

(continued)

(continued Table 13)

Factors			
4		5	
Hidden Figures	(.55)	Digit S.F.	(.65)
Mem. for Design	(.56)	Word Class.	(.64)
Digit S.B.*(h=.39)	(.41)	Logical Think.	(.57)

* Test loading on only the one factor, with more than .30 of its common factor variance accounted for on this factor.

TABLE 14

Factor Loadings of .50 and Over
Combined Group - Good Readers

Factors					
1		2		3	
Age	(.50)	Hidden Figures	(.76)	Socio-Eco.L	(.53)
Gibson Trans.	(.54)	Thurs. Id. Forms	(.52)	Gibson Lett.	(.64)
Asso. Cl. - Mem.	(.63)	Digit Span For.	(.60)	Hearing Loss	(.50)
Picture Class.	(.52)	Digit Span Back.	(.79)		
Picture Anal.	(.54)	Coop. #2* (h=.40)	(.48)		
Word Similar.	(.63)	Coop. #4* (h=.33)	(.48)		
Verbal Anal.	(.75)				

* Test loading on only the one factor, with more than .30 of its common factor variance accounted for on this factor.

(continued)

(continued Table 14)

Factors			
4		5	
Draw-A-Man	(.61)	Thurs. Id. Forms	(.63)
Picture Similar.	(.52)	Doehring	(.73)
		Logical Thinking	(.67)
		Mem. for Design	(.51)
		Bender-G.*(h=.46)	(.41)

* Test loading on only the one factor, with more than .30 of its common factor variance accounted for on this factor.

Multiple Step-wise Correlations

Multiple correlations were computed in order to isolate the tests that were the best predictors of the Reading T-Score for both poor and good readers. Table 15 presents the partial correlations from which the figures were chosen for the computation of multiple step-wise correlations. For the good readers, Digit Span Forward, Cooper #4, Memory-for-Designs, and Gibson Transformations were added on in that order. For the poor readers, Bender-Gestalt, Digit Span Forward, and Picture Classification were selected in that order. Table 16 presents the multiple correlations. Although these correlations are relatively low, each group of subjects represents only part of a total distribution of scores; viz., the low and high extremes, so that variation is smaller than usual. Thus, the .45 multiple correlation of Reading T-score with the Bender-Gestalt and the Digit Span Forward indicates that these are acceptable as predictors for the poor readers. The Picture Classification does not add any further strength to the prediction. For the good readers, the Digit Span Forward alone predicts better than any combination of scores.

That the Digit Span Forward should predict reading scores for both poor and good readers is of interest; it is quite possible that this test measures a higher ability such as the organization of information for retrieval as well as short-term memory.

Discussion

The structure of underlying factors predicted by the hypotheses was one that clearly distinguished between good and poor readers, with the isolation of visual discrimination and short-term memory factors in the poor readers and rule abstraction factors in the good readers, and sequential processing involved in all factors. The structures obtained are, indeed, different; the tests loading on the various factors for the group of poor readers are unlike those of the good readers. The weighting of tests in the description of abilities of higher level readers differs somewhat from that found with less successful readers. The factor structures, however, are not the clear hierarchies of abilities predicted. It is evident that visual discrimination is critical to both poor and good readers; the specific tests of visual discrimination that describe this factor differ for each group. Apparently visual discrimination as described in the tests of this battery consists of more than one kind of ability. The visual discrimination factor isolated for the good readers includes tests of visual search and sequencing; the visual discrimination factor isolated for poor readers involves short-term memory as the concomitant variable. While visual discrimination

TABLE 15

Partial Correlations of Reading T-Scores with 27 Variables for the Two Combined Groups

Variable	Poor Readers	Good Readers
Age	-.28	-.03
Sex	.29	-.03
Socio-Economic Level	.11	.16
Hearing Loss	-.18	.24
Draw-A-Man	-.21	.16
Bender-Gestalt*	-.40	.47
Hidden Figures	-.00	-.28
Thurstone Identical Forms	-.34	-.05
Gibson Transformations	-.09	.32
Doehring Test	.14	-.51
Digit Span Forward	-.06	-.40
Digit Span Backward	.30	.49
Memory for Designs*	-.24	-.27
Associative Clustering-Memory	.31	.35
Associative Clustering-Clustering	.25	.23
Cooper #2	.07	-.05
Cooper #4	.07	-.06
Picture Classification	.29	-.12
Picture Similarities	-.08	-.18
Picture Analogies	-.03	-.22
Picture Sequential Similarities	-.23	-.34
Word Classification	-.15	.09
Word Similarities	.13	-.07
Verbal Analogies	.15	.21
Verbal Sequential Similarities	-.00	.14
Logical Thinking	.26	.49

* A low score reflects a higher level of performance.

TABLE 16

Multiple Step-Wise Correlations
for the Two Combined Groups

A.	Good Readers	
	Digit Span Forward (+) Cooper #4	.22
	Digit Span Forward (+) Cooper #4 (+) Memory for Designs	.21
	Digit Span Forward (+) Cooper #4 (+) Memory for Designs (+) Gibson Transformations	.18
B.	Poor Readers	
	Bender-Gestalt (+) Digit Span Forward	.45
	Bender-Gestalt (+) Digit Span Forward (+) Picture Classification	.44

differentiates both groups, it is on visual search and sequencing abilities that the good readers vary and visual memory on which the poor readers vary.

Similarly, rule abstraction is an important factor to both good and poor readers; again, the tests loading on this factor differ for each group. The rule abstraction factor for the poor readers includes three visual perception tests and a language test; the factor covers a wider range of rule behavior than the abstraction of a superordinate rule covering a series of pictured or verbal instances as required in the rule abstraction tests. The rule abstraction factor for good readers is a clearer indication of this superordinate abstraction ability. It is clear that rule abstraction is a more comprehensive ability than has been described by the hypotheses; the visual discrimination involved in several of the tests of the battery may indeed require consideration and evaluation of attributes of the type described by Bruner (1957). It may be this hypothesis testing aspect of visual discrimination tasks that is involved in the apparent relatedness between tests of rule abstraction and visual discrimination for poor readers on Factor One. The correlation clusters of the Pennsylvania and St. Mary's schools considered previously also indicated the complexity of these two variables.

On the basis of results with this battery of tests, it seems reasonable to conclude that neither visual discrimination nor rule abstraction is an ability of single dimension; further, these variables inter-act. The visual discrimination abilities required of the tests were clearly at several levels; these included the recognition of a figure with few details through a rudimentary hypothesis testing, the distinguishing of minute differences in groups of figures scanned one at a time using a more complex consideration of attributes, and a visual search mechanism of the type described by Hochberg, in which large groups of symbols (printed text) are scanned and differentiated at a single glance. Tests involving rule abstraction abilities other than those described for visual discrimination required the scanning and organizing of various objects and events under an appropriate covering symbol, and the differentiating of grammatical classes.

In conclusion, it must be admitted that, while the hypotheses recognized the rule abstraction processes involved in language, rule abstraction required of visual discrimination was not considered. Similarly, visual discrimination was considered as one global factor; it has become obvious that this much-used term is a catchall label for a wide range of abilities. The factor structures of both good and poor readers reflected both the multi-dimensional nature of two variables and their inter-action.

CHAPTER IV

CONCLUSIONS AND RECOMMENDATIONS

Conclusions

The statistical analyses confront the author with results that are at once disappointing and exciting. Disappointing, because the factor structures she described in the hypotheses were far more complex than predicted; exciting, because the statistical descriptions provide even more valuable information for reading improvement than was expected.

The analyses did, indeed, demonstrate differences in the test performance of good and poor readers. The factor loadings of tests for the group of poor readers varied from those of the good readers. Such variation indicated that good readers are, as hypothesized, doing something differently. The differences between the two groups are not only in degree, as demonstrated in the mean score differences, but also in kind, as demonstrated in the factor analyses.

Visual perception and memory. It was hypothesized that poor readers would vary on tasks of memory and visual perception alone. Two factors were extracted: one involved rule abstraction and visual perception; the other, memory and visual perception.

The visual-memory factor indicates that, despite the restricted range of ability in this group, there is variation in the efficiency with which visual input is stored. In other words, these results indicate that the most seriously retarded reader, i.e., the child at the lower extreme of the distribution of poor readers, is a failure at the most rudimentary task of reading---symbol discrimination and storage.

The factor involving visual perception and rule abstraction describes for us the possible source of difficulty for these seriously retarded readers. While the relationship between rule abstraction and language was considered in the hypotheses, the relationship between rule abstraction and visual discrimination was not. It is obvious that these processes are involved in even simple pattern discrimination; there has been recognition of this fact by Bruner (1964), Neisser (1967), Gibson (1962), and Miller (1960). Their research demonstrates that the type of feature analysis required for recognition of patterns such as letters and words, is, in Bruner's terms, "...a categorization process..." (Bruner, 1964, p. 226).

Thus at the most fundamental level of reading, viz., the discrimination of graphemes, simple hypothesis testing is already required of the child. Consideration of attributes, such as those described by perceptual psychologists as "lines and angles," "concavity," "horizontality" (Neisser, 1967), or, as "a matrix of distinctive features" (Gibson, 1962), must be made if the letter is to be categorized. Indeed, before the reader can even begin to generate hypotheses about the figure, Neisser (1967) and Gibson (1963) and others assert that he must have developed the ability to focus his attention on specific areas of concern. The ability to attend to a stimulus, to localize attention to its various parts, must precede the process of pattern recognition. It is quite possible that the seriously retarded reader is deficient in the ability to attend to the stimulus as well as in the ability to analyze its features.

If, however, the child can master the letter categories, he may then proceed to the word level. Word understanding is again a feature analysis problem, involving visual discrimination, rule abstraction, and language. Gibson suggests that recognition is based upon the verbal association of spelling units; i.e., it is based upon "...clusters of graphemes in a given environment which have an invariant pronunciation..." (Gibson, 1965, p. 1071). Neisser (1967) describes word recognition as the synthesizing or construction of the visual figure and the verbal sequence, based upon a "concatenation of features"; such features may be at the word level or in smaller units. Neisser asserts that the reader makes the construction on the basis of partial cues. The child at the upper end of the distribution of poor readers and perhaps at the lower end of the distribution of good readers has reached this level of mastery.

When we consider the sentence and paragraph, it becomes more difficult to describe the role of visual discrimination or, for that matter, of any of the factors. Neisser describes the problem most well:

> "Where rapid reading is concerned, the situation is quite different. The end product of cognitive activity is not a bit of verbal behavior, but a deep cognitive structure; not a verbalized name, but a continuing silent stream of thought. Reading for meaning seems to be a kind of analysis by synthesis, a construction which builds a non-sensory structure just as 'lower levels' of cognition synthesize visual figures or spoken words."
>
> (Neisser, 1967, p. 136.)

Although it was not predicted that visual discrimination would distinguish the good readers, two factors that included visual discrimination and language tests were extracted. Apparently, the level of linguistic rule abstraction required of the language tests was too simple to differentiate this ability in the good readers; however, these tests did discriminate differences in visual search and sequencing. These factors may well indicate differences in the processing of language-in-print. Visual search and sequencing have been cited by psychologists as relevant to the higher levels of reading. The most heuristic concept of search processes in reading comprehension has been formulated by Hochberg (1965). He hypothesizes two levels, peripheral search guidance or the process through which "...low-acuity information [is] picked up in the periphery of the eye and [suggests] to the optic search system where it must move its point of clearest vision in order to get a detailed view of some potentially interesting region..."; and cognitive search guidance, or "...knowledge about what he has seen so far [which] ...provide[s] the observer with some hypotheses about where he should look in order to obtain further information..." (Hochberg, 1965, p. 36). The former is basically a visual perception process, the latter depends upon experience in the world and language. Both require hypothesis testing. Hochberg describes reading for meaning as a constructive process, as did Neisser:

> "For one thing, the skilled reader has acquired response biases, or guessing tendencies: given a few cues, he will respond as though the entire word (or perhaps an entire phrase) has been presented."
>
> (Hochberg, 1965, p. 10.)

It should be clear, from the discussion above, that the visual discrimination processes required of the reader involve hypothesis testing. Further, it must be recognized that these processes are multi-dimensional; i.e., they are not restricted to the rudimentary level of feature analysis of letters. Processing of a higher order is necessary at the most advanced stages of reading for meaning. The interaction of these higher-order visual processes with higher-order linguistic processes permits continued progress in reading.

Rule abstraction and language. A rule abstraction factor was extracted as predicted for the good readers. Within the range of good readers, rule abstraction abilities, verbal and non-verbal, distinguish the intermediate reader from the advanced readers; i.e., the reader at the "third grade plateau" from his more advanced peer. It is reasonable to assume that the behavior that is reflected in the advanced reader is skill in developing and using rules of increasing complexity; in other words, he is capable of organizing the environment through a complex hierarchy of rules of increasing inclusion.

Although it was not predicted that the rule abstraction tests would differentiate the poor readers, a factor including these tests and tests of visual discrimination and language was extracted for this group. The inter-action of rule abstraction and pattern recognition has been discussed in the previous section. Apparently, it is at this very basic level of rule behavior that the group of poor readers differs. Further information about the level of rule abstraction reflected in this factor is provided in the loading of the Cooper #4 Language Test. It was noted that the language included in this test was too simple to discriminate differences in the linguistic rule abstraction abilities of the good readers; however, its inclusion in the rule abstraction factor for the poor readers may be interpreted as reflecting differences in this group in the ability to deal with these basic syntactic rules.

Thus, two levels of general rule abstraction ability are indicated in the factor structures of the two groups. In the hypotheses, this general ability was presumed necessary for the learning of the rules of language. On the basis of these results, it may be assumed that the rudimentary level of rule abstraction found in the children at the upper end of the distribution of poor readers and at the lower end of the distribution of good readers is sufficient for them to succeed with simple text of the Subject-Verb-Object type. Such structure is considered relatively easy for even young children to master. Thus, these children are capable of some progress with printed language of S-V-O structure. As the language of the printed text increases in complexity, a higher level of rule abstraction is required. The author is proposing here that the increasing complexity of the syntactic structure of sentences in texts described as "fourth grade level" and above, requires an intricate hierarchical structuring of rules; i.e., it requires the ability to generate most sophisticated hypotheses and to develop most complex rules. The rule abstraction factor for the good readers may indicate that those at the upper end of the distribution have greater facility with complex rule behavior, and are therefore capable of analyzing higher order syntactic structures. Significantly, age was involved in this factor for the good readers; it is possible that the ability to form more complicated rule hierarchies does develop without obstacle with the passage of time in many children. Age was not involved in the rule abstraction factor for the poor readers. It is the position of the author that the ability to structure rule hierarchies does not develop in all children as a simple function of increasing age. It is obvious that leaving the development of complex rule behavior to chance rather than to the curriculum is adding to the incidence of reading retardation.

Sequential processing. As predicted, sequential processing interacted with the other factors. In the discussion above, it was indicated that sequencing skill was necessary to the visual and cognitive processing of complex units of text. The visual discrimination factors extracted for the good readers indicated such involvement.

The rule abstraction factor for the poor readers indicated that sequencing skill is equally important to what was described as "lower level" functioning with rules. The Doehring Test and the Cooper #4 Language Test load on this factor; both tests are direct measures of serial ordering. Serial ordering had been predicted as interacting with visual discrimination for the poor readers; since we have accepted rule abstraction as the underlying factor in lower-order and higher-order visual processing it would seem that serial ordering is a special function of rule behavior. That it has been described as such by perceptual and cognitive psychologists servgs to make rule behavior that much more critical a factor in reading.

Recommendations :

Based upon the results of this study and of current research in the field, the author suggests the following:

1. Far greater effort must be directed toward the articulation of visual discrimination processes involved in reading. We must design methods of instruction that will aid the child in developing visual discrimination skills appropriate to the requirements of reading at all levels: letter recognition, word recognition and comprehension of language in print. We can no longer afford to present the child with these most complex problems and hope with luck that he finds the solution for himself; in effect, children have been teaching themselves to read. The present status of instruction is primitive when compared with the information available from perceptual psychology. Educators studying the reading process are strongly urged to consult the writings in this field. One need only consider the mindless activities to which the young child is exposed to make him "ready" for reading to be convinced of the need to look elsewhere for direction. Neisser's concept of focal attention and figural synthesis, Gibson's

matrix of letter features, and Hochberg's search processes, the small sampling cited in this paper, provide us with productive sources for the re-evaluation of reading instruction at all levels. Pre-reading activities would be far more helpful if activities to facilitate attention-focusing as described by Neisser were introduced. The process of letter and word recognition would be far more predictable were activities provided for the child using feature analysis after Gibson (1963), Selfridge (1966), and Feigenbaum (1963). It is possible, then, for educators to begin immediately to implement experimental methods that will lead to the systematic structuring of the visual processes in reading. Further, educators must recognize that the most valuable source of new and relevant information about these processes is the perceptual psychologist; authentic innovation will depend upon collaboration.

2. Educators must provide the child with the opportunity to develop and use rules of increasing complexity. The curriculum must be designed with systematic exposure to activities and materials that provide the child with the opportunity to test his own hypotheses. Further, these activities and materials must be carefully structured so that the child can build a hierarchical structure that will meet his needs in transactions with the environment. Research in both perceptual and cognitive psychology (and the results of this study) indicatesthat rule behavior is critical to feature analysis of simple objects, serial ordering of input, complex organization of events. On the basis of this study, it has become clear to the author that every aspect of reading, including the perceptual processes, the linguistic processes and processes unique to the translation of language-in-print, are all dependent upon success at some level of rule abstraction. A curriculum that merely feeds already structured information to a child, and evaluates the success of his learning on the basis of the correct repetition of that information, is not preparing him for the mastery of the most complex reading tasks as described above by Hochberg and Neisser. Many educators have recognized this need, and collaborating with cognitive psychologists, are developing new methods and materials to enhance the child's cognitive processes. Such an instructional approach must become a familiar part of the classroom before we can hope for change.

3. It has been mentioned *ad infinitum* that language is a rule-abstraction process; it should, then, be presented as such to the child. New approaches are being devised in language instruction that take advantage of the information available from the field of linguistics. Further investigation is needed, however, to determine the sentence structures beyond those of S-V-O that are obstacles to the poor reader. If we can describe such structures, then instructional procedures can be devised to help the child master these elements of his language.

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APPENDIX

Since several new tests were constructed and administered for the first time during the project, reliabilities were computed. These are reported in Table A. Caution must be exercised in interpreting these data, however, since such analyses are typically based upon the entire score distribution. These are based upon a highly restricted group, at either the lowest or highest score extremes.

Despite this limited range of ability, the reliabilities for the poor readers are quite respectable. The reliabilities for the good readers are low in some cases, reflecting the failure of some of the tests to discriminate among the subjects; i.e., most of the good readers answered <u>all</u> items correctly. Statistical reliability is lowered considerably where there is low variability within the group. Inspection of these tests in the correlation matrices, upon which the factor analyses are based, shows correlations as low as .20; however, there are also many as high as .63. Apparently, even within this restricted variability, there were relationships among the scores of the good readers; it remained for the factor analyses to demonstrate these relationships.

TABLE A

Reliabilities of Tests Constructed by Project Personnel

Test	Poor Readers	Good Readers
Picture Classification	.31	.42
Picture Similarities	.56	.34
Picture Analogies	.75	.32
Picture Sequential Similarities	.26	.12
Word Classification	.63	.49
Word Similarities	.69	.11
Verbal Analogies	.68	.50
Verbal Sequential Similarities	.48	.15
Logical Thinking	.57	.19