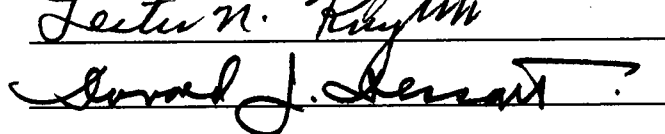


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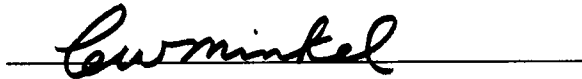
I am submitting herewith a dissertation written by Mary Kay Bordner entitled "The Development of Analogical Reasoning Abilities in Reading Disabled Students." I have examined the final copy of this dissertation for form and content and recommend that it be accepted in partial fulfillment of the requirements for the degree of Doctor of Philosophy with a major in Curriculum and Instruction.


J. Estill Alexander, Major Professor

We have read this dissertation
and recommend its acceptance.


Lester N. Rynkiewicz


Accepted for the Council:


Associate Vice Chancellor
and Dean of the Graduate School

THE DEVELOPMENT OF ANALOGICAL REASONING ABILITIES
IN READING DISABLED STUDENTS

A Dissertation
Presented for the
Ph. D
Degree
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Mary Kay Bordner

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DEDICATION

This dissertation is dedicated to my parents, who always placed a high value on education, and who felt that I could accomplish anything I set out to do.

This dissertation is also dedicated to my husband and three children who were unfailing in their encouragement and support.

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ABSTRACT

Analogical reasoning is a very complex process which requires the learner to focus on the underlying relationships between two concepts. Numerous research studies have demonstrated the usefulness of analogy in the classroom. However, there are few research studies concerned with analogical reasoning in which the primary focus is the reading ability of the students. The overall purpose of this study was to examine the analogical reasoning abilities of reading disabled students.

The specific research questions were:

1. Are reading disabled students able to develop or improve their ability to reason by analogy?
2. Is there a relationship between a reading disabled student's receptive vocabulary and his ability to solve analogy problems?
3. Is there a relationship between a reading disabled student's age and his ability to solve analogy problems?
4. Is there a relationship between a reading disabled student's general intelligence and his ability to solve analogy problems?
5. Is there a relationship between the severity of a student's reading disability and his ability to solve analogy problems?

In the present study, data were collected through participant observation, audio taping, and objective testing. These different methods were utilized in order to obtain a more complete picture of the analogical reasoning ability of these reading disabled students. The following conclusions can be drawn from the findings of this research study:

1. Reading disabled students were able to improve or develop the ability to reason by analogy.
2. There was little, if any, relationship between a reading disabled student's ability to reason by analogy and his receptive vocabulary.
3. There was a strong relationship between a reading disabled student's age and his ability to reason by analogy.
4. There was little, if any, relationship between a reading disabled student's ability to reason by analogy and his general intelligence.
5. There was little, if any, relationship between a reading disabled student's ability to reason by analogy and the severity of his reading disability.

A model of analogical reasoning, which is intended to explain how reading disabled elementary school students complete verbal analogy problems, was proposed. An instructional procedure for developing or improving the analogical reasoning abilities of reading disabled students was also proposed.

TABLE OF CONTENTS

CHAPTER	PAGE
I. INTRODUCTION	1
The Problem	4
The Purpose	7
Assumptions	8
Definition of Terms	9
Overview of the Study	11
Organization of the Study	13
II. REVIEW OF THE LITERATURE	15
Introduction	15
Theoretical Issues	16
Models of Analogical Reasoning	16
Domain Distance	22
Development of Analogical Reasoning Abilities	24
School Age Children	24
Children Younger Than Eleven.....	27
Improving Analogical Reasoning Ability ...	30
Average Ability Students	30
Gifted Students	32
Language Impaired Students	34
Learning Disabled Students	36
Analogy in the Classroom	38
Acquisition of Knowledge	38
Using Analogy to Decode Words	44
Analogy as a Comprehension Strategy .	50
Summary of Research Results	52
III. MEASURING INSTRUMENTS AND PROCEDURES OF THE STUDY	56
Introduction	56
Subjects	56
Measuring Instruments	58
Gates McGinitie Reading Tests	59
Slosson Intelligence Test	60
Peabody Picture Vocabulary Test- Revised	61
Woodcock Reading Mastery Tests- Revised	63
Harris and Sipay Procedure	65
Reading Expectancy Age	65
Reading Expectancy Quotient	66
Reading Quotient	67

Data Analysis Procedures	69
Data Collection for Question One	69
Data Collection for Questions	
Two Through Five	73
Specific Procedures	75
Timetable for the Study	75
Instructional Method	77
IV. FINDINGS	83
Introduction	83
Findings for Question One	86
Information from the Audio Tapes	86
A Theory of Analogical	
Reasoning	86
Instructor-led Solutions	87
Student Mistakes	92
The Justifications	98
Analogy as a Diagnostic Tool ...	103
The Analogy Problem	107
Information from the Testing	113
Percent of Improvement	113
Comparing the Pretest and	
Posttest Scores	115
Findings for Question Two	116
Findings for Question Three	117
Findings for Question Four	117
Findings for Question Five	120
Summary	122
V. SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS	124
Summary	124
Introduction	124
Research Questions	125
Data Collection	126
Conclusions	127
A Model of Analogical Reasoning	127
An Instructional Procedure	130
Improvement of Analogical	
Reasoning Abilities	132
Conclusions for Question One ...	132
Analogy and Receptive Vocabulary	142
Conclusions for Question Two ...	142
Analogy and Age	144
Conclusions for Question Three .	144
Analogy and Intelligence	148
Conclusions for Question Four ..	148
Analogy and Severity of Reading	
Disability	150
Conclusions for Question Five ..	150

Recommendations	152
For Research	152
For Instruction	155
BIBLIOGRAPHY	159
APPENDIX	171
Analogies used in the Study	172
Informed Consent Form	189
Limitations of the Study	190
VITA	191

LIST OF TABLES

TABLE	PAGE
1. Distinguishing between disabled readers, underachievers, and slow learners	68
2. The use of the mapping step in student solutions	87
3. A comparison of the student's pretest and posttest scores on the Woodcock Reading Mastery Tests-Revised (analogy section)	115

LIST OF FIGURES

FIGURE	PAGE
1. Scatter diagram for Question Two. The correlation between a student's receptive vocabulary and his performance on analogy problems	118
2. Scatter diagram for Question Three. The correlation between a student's age and his performance on analogy problems	119
3. Scatter diagram for Question Four. The correlation between a student's general intelligence and his performance on analogy problems	121
4. Scatter diagram for Question Five. The correlation between the severity of a student's reading disability and his performance on analogy problems	123
5. A Model of Analogical Reasoning	129

CHAPTER I

INTRODUCTION

The cognitive processes used in analogical reasoning have been examined extensively during the past century. Defined as "the ability to see relationships between seemingly dissimilar concepts or experiences," analogical reasoning is more than a simple memorization of facts. It is a very complex process which requires the learner to focus on the underlying relationships between two concepts. During the process of reasoning by analogy, information is transferred from one body of knowledge to another through the formation of one-on-one correspondences between the two situations.

Researchers in the field of cognitive development have often theorized that there is a close relationship between intelligence as measured on mental tests and the ability to reason by analogy. William James (1890), the famous American psychologist, wrote in his classic Principles of Psychology, "A native talent for perceiving analogies is the leading fact in genius of every order. It is one of the ultimate foundation pillars of the intellectual life" (p. 345).

Charles Spearman (1927) predicated the idea that three primary principles controlled all knowing and all cognitive growth. The second and third principles, which were the education of relations and the education of correlates, play an

essential role in the ability to reason by analogy. Spearman believed that a person's performance on an analogy test was almost a pure measure of the g (general) factor of intelligence. Louis L. Thurstone (1938) developed a battery of intelligence tests, known as the Primary Mental Abilities, in which he used the verbal analogy as a means of validating his theory of intelligence. The verbal analogy, which is found on many intelligence tests, has long been considered the single best method for measuring general intelligence.

Numerous educational research studies have demonstrated the usefulness of analogy in the classroom. Teachers often use analogies to help their students understand new concepts. By introducing a new concept in association with a familiar concept, the student often can understand the new concept more easily. Abstract or complex concepts are more readily understood when they are compared to concrete items. An analogy can be used to make the connection between the abstract concept and the concrete item. The use of analogy permits the learner to ignore surface attributes, which may be disparate, and focus on the core relationships shared by the concepts or the items. Thus, analogies can explain relationships between concepts that cannot be explained as clearly in any other manner.

Analogical reasoning can be used as an instrument for enriching, modifying, and restructuring the knowledge base of students (Vosniadou and Ortony, 1989; Vosniadou, 1988; Bean

et al., 1985). Because analogies contain a built-in context, they facilitate the incorporation of new information into a student's background knowledge (Bacharach, 1988; Andrews, 1987; Alexander, 1984). A study by Hayes and Tierney (1982) found that analogies being used to build background knowledge also had an influence on the students' ability to comprehend the text.

Schools now emphasize the development of thinking and reasoning skills in their students. Analogies have been used with students from preschool to college age, with students of varying ability levels, and in most subject areas. Analogies encourage students to think creatively by using multiple meanings of words, to view concepts from new perspectives, and to focus on specific details (Bellows, 1980).

The past fifteen years have seen an increased awareness of the analogical reasoning process as it relates to the cognitive development of children. Analogy strategies are utilized by learners of all ages as a means of vocabulary development in decoding unknown words (Goswami, 1990; Greenwood, 1988; Wolff et al., 1985; Kay and Marcel, 1981; Baron, 1979; Marsh et al., 1977). Even preschool children are able to reason by analogy if they have acquired the knowledge base needed to make the comparisons (Goswami and Brown, 1989; Nippold and Sullivan, 1987; Holyoak et al., 1984). Data from numerous research studies have indicated that the ability to reason by analogy is a skill that improves throughout the

elementary, middle, and high school years (Kulikowich and Alexander, 1990; Nippold and Sullivan, 1987; Alexander et al., 1986; Gentner and Toupin, 1986; Nippold, 1986; Rummel and Dykstra, 1983; Sternberg and Downing, 1982; Sternberg and Nigro, 1980; Levinson and Carpenter, 1974).

THE PROBLEM

There are few research studies concerned with analogical reasoning in which the primary focus is the reading ability of the subjects. Alexander et al. (1986) compared average ability tenth grade readers with eighth grade students who were reading two years above grade level. Results indicated that the eighth grade gifted readers outperformed the older learners on an analogy task after training in solving analogical reasoning problems. Goswami (1986) compared children of three different reading levels (prereader, first, and second) in their ability to use analogy in reading real and nonsense words. The results of the Goswami study demonstrated that even beginning readers are able to use analogy to read single words.

A study by Manis et al. (1986) compared fifth and sixth grade dyslexic readers with younger normal readers. Results of this study indicated that normal readers were more likely to notice and make analogies to known words which were embedded in nonsense words than dyslexic readers. Wolff et

al. (1985) carried out a study involving second grade normal readers and fifth grade reading disabled students. The results of this study demonstrated that reading disabled students were able to use analogy strategies to decode unknown words. White and Alexander (1984) conducted a study with average fourth and sixth grade readers to determine if the students could improve their ability to solve analogy problems. Results indicated that training, using a direct instruction model, improved the analogical reasoning abilities of the students.

Researchers disagree as to whether training in solving analogy problems can transfer to a reading comprehension task. Judy et al. (1988) demonstrated that training in solving analogy problems can transfer to a reading comprehension task. Alexander et al. (1983) conducted a study which did not find any transfer between training in solving analogy problems and an inferential comprehension task. One reason for the contrasting findings from these studies might be the fact that different methods and different tasks were utilized to train and evaluate the students. Reliable information regarding any relationship between reading comprehension and training in analogical reasoning would prove invaluable to educators and others who work with reading disabled students.

While the development of analogical reasoning abilities in students who are average readers has been examined in numerous research studies, few studies have focused on

disabled readers. Since analogical reasoning is thought to play an important role in a student's cognitive development, more information is needed with regard to its development in disabled readers. Verbal analogy problems, which are included on many reading and intelligence tests, may be especially difficult for reading disabled students. These students are already at a disadvantage on these tests because of the written format of the tests. Research results reveal that reading disabled students seem to have limitations at the lexical level when compared with normal readers of the same age. Reading disabled students have fewer items represented in their lexicons and may have trouble recalling to memory the items which are there (Snowling, 1987; Stanovich, 1985). Verbal analogies often require learners to understand subtle differences in word meanings, which might be a very difficult task for reading disabled students (Nippold, 1986).

Another problem area for reading disabled students may lie in the logical relationships found in verbal analogies. These students tend to think literally, and they may have trouble transferring meaning from one domain to another. The student may know the meanings of all the words included in the analogy but still be unable to solve the problem if he does not understand the nature of an analogous relationship (Rothschild, 1987).

THE PURPOSE

Much of today's educational research is interested in the cognitive development of children. Analogical reasoning has long been considered to be an integral part of higher level cognitive thinking. Thus, a well-conducted study in this area has the potential to contribute valuable information to cognitive research in education. Since the number of students who are diagnosed as reading disabled is increasing each year, information is especially needed about the development of higher level cognitive abilities in these students. This descriptive correlational study will investigate the following questions:

- A. Are reading disabled students able to develop or improve the ability to reason by analogy?
- B. Is there a relationship between a reading disabled student's receptive vocabulary and his ability to solve analogy problems?
- C. Is there a relationship between a reading disabled student's age and his ability to solve analogy problems?
- D. Is there a relationship between a reading disabled student's general intelligence and his ability to solve analogy problems?

- E. Is there a relationship between the severity of a student's reading disability and his ability to solve analogy problems?

ASSUMPTIONS

For the purpose of this study it is assumed:

- A. that the test scores will reflect the student's ability on the specific areas tested.
- B. that a measure of a student's verbal analogy performance reflects his analogical reasoning ability.
- C. that the disabled readers (aged seven to twelve) enrolled in The University of Tennessee Reading Center during the spring, 1989 semester are comparable to other corrective and remedial readers in similar programs.
- D. that all data from the tests are interval data.
- E. that the analysis of the data will yield information that will be generalizable, not in a statistical way, but from a pragmatic viewpoint to similar populations.
- F. that a coefficient correlation above .400 indicates a relationship between the two variables, and that

a correlation above .600 indicates a strong relationship between the two variables.

DEFINITION OF TERMS

Base domain-the domain in an analogy that serves as the source of knowledge.

Dyslexia-severe reading disability that may represent loss of reading competency following brain injury or it may represent a developmental failure to profit from reading instruction; also employed broadly for reading disability (Harris and Sipay, 1985).

Far Domain analogies-also referred to as between domain analogies; when the base and target domains have few features in common; there are few obvious links between one's knowledge of these two topics (Halpern et al., 1990).

Forced Choice Analogies-analogies which provide several answer choices for the student to choose from.

Learning disability-significant difficulty in the acquisition of listening, speaking, reading,

spelling, writing, or arithmetic skills; causation is usually attributed to central nervous system deficits or dysfunctions (Harris and Sipay, 1985).

Near Domain analogies-also referred to as within domain analogies; there are similarities in the surface features between the base and target domains; the two domains involve similar topics (Halpern et al., 1990).

Reading disabled-students whose general level of reading ability is significantly below expectancy for their age and intelligence and is disparate with their cultural, linguistic, and educational experience (Harris and Sipay, 1985).

Schema theory-a theory which attempts to explain how knowledge is represented in the mind and how those representations facilitate the use of knowledge (Harris and Sipay, 1985).

Schemata-units of knowledge in the mind; these units summarize what one knows about a concept as well as how the pieces of information are related (Harris and Sipay, 1985).

Self Generating Analogies-analogies in which the student is required to furnish the answer; no answer choices are provided.

Target Domain-the domain that is being explained.

OVERVIEW OF THE STUDY

Correlational research involves the collection of data in order to determine to what degree a relationship exists between two quantifiable variables. The degree of relationship between the two variables is expressed as a correlational coefficient (Gay, 1987). Data were collected from thirty-eight students enrolled in The University of Tennessee Reading Center tutoring program during the spring 1989 semester for the present research study.

The students attended twenty four one-hour instructional sessions from January through May, 1989. The Gates MacGinitie Reading Test and the Woodcock Reading Mastery Test (analogy section) were administered to each student in a group setting during the first two weeks of classes. After each student was given the pretest for analogies, the last ten to fifteen minutes of each instructional period was devoted to the development of analogical reasoning skills in these students. It was believed that improving the students' ability to complete verbal analogy problems would improve the students'

overall ability to reason by analogy. All analogy instruction and testing was oral in order that a student's reading ability would not be a major factor in the results of either the instruction or the testing.

During the months of February and March, the Peabody Picture Vocabulary Test-Revised and the Slosson Intelligence Test was administered individually to each student. The week before the final testing, the students reviewed the analogies by completing verbal analogy problems on computers. The analogy section of the Woodcock Reading Mastery Test and the Gates MacGinitie Reading Test (different forms) were administered to the students the final week of classes.

The instruction in analogical reasoning was based on the process theorized by Robert J. Sternberg (1977). This process involved using the four steps of encoding, inferring, mapping, and application to complete the verbal analogy problems. The instruction included a discussion of the meanings of the words in the analogy, teacher modeling of the four step process used to complete the verbal analogies, student modeling of the four step process, student completion of the analogy problems with teacher feedback, and independent student practice with verbal analogy problems.

All tutoring sessions were tape recorded and these tapes were transcribed. The analogies were read orally to the students if they did not recognize the words. The students were required to verbalize their thinking processes as they

completed the verbal analogy problems. The transcripts were examined to determine which steps the students used while completing the verbal analogy problems. The researcher used these audio tapes as the basis for proposing a model of analogical reasoning. An instructional procedure for teachers to use to improve their students' ability to complete verbal analogies was developed during the study.

A procedure recommended by Harris and Sipay (1985) was used to determine each student's expected reading level. Each student's actual reading level was determined by the Gates MacGinitie Reading Test. These two scores were compared in order to compute the difference between the expected reading level and the actual reading level of each student. This number was used to determine the severity of the student's reading disability.

ORGANIZATION OF THE STUDY

Chapter I presented an introduction to the study including the following: (1) a statement of the problem, (2) a statement of the purpose for the study, (3) any assumptions (4) a definition of terms used in the study, and, (5) a brief description of the methodology employed in the study.

Chapter II will present a review of the literature and research related to the present study. The emphasis will be

on any studies during the past decade that are related to the development of analogical reasoning abilities in disabled readers.

Chapter III will describe the measuring instruments, statistical procedures, and data analysis that was used in this study. Chapter IV will present the findings from the study. Chapter V will contain a summary of the study. It will also present the conclusions that were drawn from the data and implications from these findings for subsequent research and instruction.

CHAPTER II

REVIEW OF THE LITERATURE

INTRODUCTION

In reviewing the literature on analogical reasoning, the researcher located more than one hundred research studies, most of which were conducted during the past thirty years. Experiments which provided the foundation for the present study as well as those which were related to the same general topic were included in this review. Although there are several theoretical models of analogical reasoning, the present study includes details from only two of the models. Sternberg's componential model of analogical reasoning (1977) was included because this model formed the basis for the instructional method used to teach the students. And, the Rumelhart and Abrahamson (1973) model was included because it professed to show how students complete verbal analogy problems, which were used in the present study to measure the analogical reasoning ability of the students.

Chapter II has been divided into six main sections. The first section is an introduction to the review of the literature. The second section is a discussion about several theoretical issues surrounding analogical reasoning, including the models of analogical reasoning and the effects of domain

distance on the reasoning abilities of students. The next section contains information regarding the development of analogical reasoning abilities in students of different ages. This section specifically examines the age at which students begin to develop the ability to reason by analogy as well as whether this ability continues to improve as the students reach adulthood. The subsequent section contains research studies which investigate the improvement of the analogical reasoning abilities of students with different ability levels. The section looks at language impaired and learning disabled students, which is especially relevant to the present research, as well as average ability and gifted students. The fifth section is a survey of analogy in the classroom, with special emphasis on analogy as a means of decoding words and as a comprehension strategy. It contains many studies which demonstrate the various ways analogy is being used in the classroom by educators today. The final section of Chapter II contains a summary of the review of the literature.

THEORETICAL ISSUES

Models of Analogical Reasoning

A theory of analogical reasoning should explain how the meaning of an analogy is obtained from the meaning of its components. The strength of an analogy is found in the

relational structure which is formed during the mapping process rather than in the number of shared features between the two domains (Gentner, 1983). The relations in an analogy can be mapped at several different levels of abstraction, which Gick and Holyoak (1983) compare to Kintsch and Van Dijk's macrostructures. Thus, an analogy might be complete at the macrostructure level and incomplete at more specific levels. Several researchers have attempted to explain the process of analogical reasoning as well as to examine the individual components of reasoning by analogy.

Sternberg (1977) proposed a componential theory of analogical reasoning which contained six information-processing components. In the first component, encoding, the stimuli are changed into internal representations and stored in working memory. The second component, inference, is the process where a rule is formulated which relates the A and B terms of the analogy. Mapping, the third component, relates the domain of the analogy to the range by formulating the rule which connects the A and C terms. The fourth component, application, is the process whereby an analogous rule is formed which permits the subject to match the C and D terms. The information from these three components is stored in working memory at each step of the process. Justification, the fifth component, is the only optional component. At times, in justification, the subject is forced to choose an answer which is not identical to the ideal but is the closest

of the alternatives. In the final component, preparation-response, the subject monitors the solution process and translates the solution into a response. Sternberg's model of analogical reasoning has received the most attention in the research literature, and has formed the basis for instructional procedures in analogical reasoning in several research studies, including the present study.

Four experiments were conducted by McConaghy and Kirby (1987) to determine how well Sternberg's componential model of analogical reasoning could be applied to subjects with disparate intellectual abilities. The results of this study indicated that Sternberg's model furnishes a valid explanation of how above average subjects solve analogies. However, the model does not account as well for the analogical reasoning performance of subjects with below average intelligence.

A 1988 study by Sheard and Readence examined the inference and mapping components found in Sternberg's componential theory of analogical reasoning. The subjects in this study were eighth graders and college students. The specific purpose of the study was to decide whether both the inference and the mapping processes were needed in order to solve verbal analogies. The findings indicated that only one of these two processes was needed to solve verbal analogies. The students were no more likely to solve the analogy if both the mapping and inference relations were known or if just one of these relations was known.

Grudin (1980) conducted a study to examine which strategies college students used to solve verbal analogy problems. His findings indicated that discovering the relationship between the A and C terms can improve the students' performance on verbal analogy problems. Grudin suggested that the subjects initially examined the relation between the A and B terms of the analogy. If they were unable to complete the analogy using this information, they then switched to an examination of the the relation between the A and C terms.

Gentner and Toupin (1986) conducted a study to examine the development of systematicity in analogy. The researchers' definition of systematicity was, " a base predicate that belongs to a mappable system of mutually interconnected relations is more likely to be imported into the target than is an isolated predicate" (p. 280). The specific purpose of the study was to discover at what age children, who were completing a transfer task, would benefit from the presence of a system of mutually constraining relations. The subjects in this study were two groups of children, aged four to six and eight to ten. The children were asked to act out stories by transferring a story plot from one set of characters to another. The findings of this study suggest that systematicity is a part of the mapping process. It is generally accepted that there is some type of higher order constraining structure that determines the utility of an

analogy for learning and transfer. The researchers hypothesized that this higher order constraining structure guided the mapping of the lower order relations and provided the learner with a means of checking the accuracy of the mapping. Thus, systematicity should aid in the mapping process of analogical reasoning. These findings provided evidence for the effects of systematicity in the accuracy of the eight and ten year old's mappings, but not for the younger children's mappings. This implied that the younger children were not developmentally able to benefit from the constraining structure which systematicity provided.

Gentner's (1983) theory of analogical reasoning, called structure mapping, included the systematicity principle. The primary contention of this theory is that in analogy the relations between objects, rather than the attributes between objects, are mapped from the base to the target domain. The relations which are mapped are those that are constrained by the higher order relations that belong to the mapping (the systematicity principle). The constraints are based on the structure of the knowledge representation rather than on the specific content of the domain. In contrast, a 1988 study by Zook found inadequacies in the structure mapping theory. The results of the Zook study indicated that third grade students map object attributes and isolate base relations as well as relational systems when reasoning by analogy.

Rumelhart and Abrahamson (1973) proposed a model of analogical reasoning which included the premise that the semantic relationships among specific sets of concepts can be represented by a multidimensional structure. Verbal analogies using animal names were chosen for this study, which was conducted with college students. The researcher felt that this study was relevant to the present research because the model of analogical reasoning which was proposed in this study explained the reasoning processes students utilize to complete verbal analogy problems. Rumelhart and Abrahamson viewed analogical reasoning as a "type of similarity judgment in which not only the magnitude of the distance but also the direction must be indicated" (p. 4). The model is based on the classic type of proportional analogy problem in which A is to B as C is to D. The theoretical model for analogical reasoning included the following assumptions:

A1 There is a point in a multidimensional space which corresponds to each element of an analogy problem.

A2 The ideal solution to an analogy is that point in the space which is located the same vector distance from C as B is located from A.

A3 The closer an alternative is to the ideal analogy solution, the greater the probability it will be selected as the best answer.

This theory was substantiated in the two experiments which were conducted in the study. The researchers stated that this theory of analogical reasoning was not complex enough to explain all the types of semantic relations which are found in analogical reasoning. Rather, this was a theory of analogical reasoning which may explain the types of semantic relationships which are found in verbal analogy problems as well as the processes students use to solve these problems.

The information gained from these research studies varied, depending on the focus of the study. Although Sternberg, Rumelhart and Abrahamson, and Gentner all proposed theories of analogical reasoning, no two approached the topic from the same perspective. In any case, no definitive answers will be forthcoming until more information is available concerning the cognitive processes related to analogical reasoning.

Domain Distance

A study by Halpern et al. (1990) investigated the effect of domain distance on the comprehension and recall of a scientific text. In this study, the subjects read three scientific passages which contained either near or far domain analogies. The subjects were asked test questions immediately after reading the passages and again one week later. Findings

from this study showed that the far domain analogies were more effective in improving the comprehension and recall of the complex scientific passages. The researchers theorized that far domain analogies required the subjects to search for structural relationships. Comprehension often requires readers to make inferences about information that is not specifically stated in written passages. Because of these two factors, the far domain analogies used in this study improved the ability of the subjects to infer information that was not explicitly stated in the passages.

Another study involving remote domains was conducted by Gick and Holyoak (1980). The purpose of this study was to investigate subjects' use of analogies between remote domains in order to solve problems. The subjects in this study were given a story analogy which described a problem and its solution. They were then observed using this analogy to solve a target problem. Findings from this study demonstrated that an analogous problem from a very different domain can be used to solve problems. However, these subjects often failed to notice the relevance of a solution to a target problem spontaneously. The main problem with using an analogy between remote domains is in joining the two disparate bodies of knowledge into one unit. And, the initial step in this process is to recognize the relevance of the two situations, which may not be apparent at first glance.

DEVELOPMENT OF ANALOGICAL REASONING ABILITIES

School-Age Children

During the past forty years, many researchers have been interested in the development of cognitive abilities in children. Jean Piaget, a famous Swiss psychologist, spent most of his life studying how children learn and think. In his book, Psychology of Intelligence (1950), Piaget stated, "reflective thought exists from the age of 11-12 years, from the time when the subject becomes capable of reasoning in a hypothetico-deductive manner" (p. 148). Piaget referred to this stage of development in children as the period of formal operations. Several research studies have used analogical reasoning as a means of verifying the existence of developmental changes in a child's reasoning ability at about this age.

In 1980, Sternberg and Nigro conducted a study to investigate developmental changes in children's performances on verbal analogy problems. The students, who ranged from third graders to college students, displayed two levels of performance on the analogy problems. In the first level of performance the solutions were mainly associative. The ages of the students in this group were approximately the same as Piaget's period of concrete operations. The reasoning at this level was incomplete, as was evidenced by the students'

inability to understand all of the relations between the terms of the analogies. In the second level of performance, which was approximately the same as Piaget's period of formal operations, the students were able to relate fully both sets of terms in the analogies. Sternberg and Nigro hypothesized that this older group of students was solving the analogies by using verbal reasoning rather than word associations. A 1980 study by Enyeart, conducted with college students, provided further evidence that analogical reasoning is related to formal operational thought.

Goldman et al. (1982) found similar results in the two studies they conducted. The purpose of these studies was to identify individual differences in the verbal analogical reasoning performance of eight to eleven year old students. The less skilled students, as measured by their performance on the verbal analogy task, were more susceptible to free associates of the stem or the C term. The researchers felt that the less skilled students were more susceptible to distractor items because these students possessed a weaker understanding of the nature of analogy. These less skilled reasoners may have had an associative understanding of analogy rather than a complete understanding of the analogical reasoning process.

A series of experiments was conducted by Gentile et al. (1977) to determine whether children's analogy solutions were predictable from the rankings of the relatedness of the words

in the analogy choices. Achenbach's Children's Associative Responding Test (1970) was used to identify children who relied on free association rather than analogical reasoning to complete verbal analogy problems. Results of these experiments showed that analogical reasoning is largely an associative process. The researchers proposed that analogical reasoning and associative responding share many of the same component processes and are not two separate mechanisms.

The purpose of a 1982 study by Sternberg and Downing was to determine if children exhibited further strategy development in their ability to reason by analogy after they reached the ages of Piaget's period of formal operations. The investigators studied adolescents' ability to complete analogies between analogies, or higher order analogies. Data for this study were obtained from eighth graders, eleventh graders, and college freshmen. Results indicated a developmental trend away from the use of associative relations and toward the use of analogical relations. Mapping, which has been shown to be the most difficult operation in analogical reasoning (Sternberg and Rifkin, 1979) was the final operation to develop in this study. The development of the ability to solve higher order analogies in adolescents appeared to resemble the development of the ability to solve lower order analogies in younger students. Thus, these results indicated that there were developmental changes in the

strategies used in analogical reasoning even after students reach Piaget's ages of formal operations.

All of these studies seem to provide evidence for a developmental trend in the analogical reasoning abilities of children. This trend is away from a reliance on the association of the concepts involved in the analogies and toward a complete understanding of the nature of reasoning by analogy. Although most research studies are in agreement concerning the existence of a developmental trend in the ability to reason by analogy, there is some disagreement as to when this ability first emerges. Piaget might theorize that the ability to reason by analogy begins to emerge during the period of concrete operations and becomes fully developed during the period of formal operations. Other researchers might propose that the ability to reason by analogy is evident in children's behavior at a much earlier age.

Children Younger than Eleven

Recently, educational researchers have studied whether children younger than eleven years of age are able to reason by analogy. Young children have been studied in various settings as well as by many different methods to assess their reasoning ability. Two experiments by Goswami and Brown (1989) studied whether three, four, and six year old children were able to reason by analogy. In this study, the children

were given the first three pictures in a four picture sequence. They were then asked to choose, from among five alternatives, the picture which would complete the sequence. The results of this study provided evidence that children as young as three years old are able to complete an analogy task when they understand the relations used in the analogy. Three other experiments in this study furnished information about the role of surface similarity in reasoning by analogy. Many of these children were able to solve the analogies without surface similarity cues. The researchers theorized that when the relations were simple and familiar to the children, surface similarity did not play a significant role in solving the analogy. The importance of surface similarity seemed to depend on the difficulty of the relations in the analogy.

Davison (1988) conducted a study to determine whether disadvantaged preschool children would use analogies in a structured communication task. The task involved describing an object well enough so that a person behind a visor could identify the object. In this communication task, fifty-four of the seventy children used analogies to describe the objects. This is an indication that at least some preschool children have developed the ability to reason by analogy in this type of situation.

One purpose of a 1987 experiment by Nippold and Sullivan was to determine whether young children had developed the ability to complete a verbal analogy task. This type of task

was chosen because a previous study by Sternberg and Nigro (1980) demonstrated that verbal analogies which describe functional relationships were the easiest for children to understand. The researchers evaluated the words in the analogies to ensure that they were not too difficult for the children, aged five to seven, to understand. The findings in this experiment revealed that children as young as five years old were able to comprehend verbal analogies as long as they knew the meanings of the words that were being used in the analogies.

Brown et al. (1986) studied three-to-five year old children to discover whether the children were able to transfer solutions between similar story problems. Findings from this study demonstrated that children as young as three years old were able to reason by analogy provided they had the knowledge base necessary to make the comparison between the two situations. It was also important that the analogical reasoning task did not overwhelm the processing abilities of the young children, which were not as fully developed as the processing abilities of older children.

Holyoak et al. (1984) conducted similar experiments involving story problems with two groups of children. The younger group of children were preschool and kindergarten children. The older group of students were fifth and sixth graders. The students were asked to solve a problem which had several different solutions. A story that included an

analogous problem as well as its solution was read to some of the students before they attempted to solve the problem. Results of the experiments demonstrated that preschoolers were able to use analogies to solve problems, even when there was not a high degree of perceptual and functional similarity between the base and the target analogs. These results replicated the findings of the Goswami and Brown (1989) study in regard to the role of similarity in reasoning by analogy.

The findings from these experiments provide evidence that children as young as three years old show an emerging ability to reason by analogy. This ability was not as stable or as well developed as the analogical reasoning ability of older children, but it has been demonstrated in many different situations. Processing limitations in very young children may be one limiting factor in their ability to reason by analogy. Another restricting factor is the knowledge base of these children. A child cannot discover the relations between the concepts in the analogy if he lacks the knowledge base necessary to make the comparisons.

IMPROVING ANALOGICAL REASONING ABILITY

Average Ability Students

Many research studies have demonstrated that students of different ages and ability levels can improve their ability

to reason by analogy if they are given the proper instruction. An experiment by Alexander et al. (1986) examined the results of instruction in solving verbal analogies on the performance of fourth, eighth, and tenth grade students on a verbal analogy task. A direct instruction method based on Sternberg's (1977) componential model was used with the students. The fourth and tenth grade students were average readers but the eighth grade students were reading approximately two years above grade level. The findings of the experiment clearly showed that componential training in analogical reasoning was effective in improving the students' performances on verbal analogy problems. After the training, the gifted eighth graders outperformed the average ability tenth graders on the verbal analogy problems. This indicated that the gifted eighth graders benefitted more from the training than did the average ability tenth graders.

White and Alexander (1984) conducted an experiment to determine the effects of direct instruction in analogical reasoning on the performance of fourth and sixth grade average readers on an analogical reasoning task. Again, the direct instruction method was based on Sternberg's componential model of analogical reasoning. The instructional materials included concrete and abstract drawings as well as linguistic and nonlinguistic analogies. Results of the experiment indicated that the students who received this instruction significantly improved their ability to solve analogy problems.

A 1974 study by Levinson and Carpenter investigated the development of analogical reasoning abilities in nine, twelve, and fifteen year old students. Quasi-analogies, which present the problem in the form of a sentence, and true analogies, which present the problem in the form of a proportion, were used in this study. The purpose of the study was to compare the students' performance on the quasi-analogies and the true analogies. The twelve and fifteen year old students scored higher than the nine year old students on the verbal analogy tasks. Results indicated that quasi-analogies may provide information which improved the student's performance on the true analogies. Thus, quasi-analogies may be used to facilitate the development of analogical reasoning ability in students who are unable to complete true analogies.

Gifted Students

A study by Kulikowich and Alexander (1990) compared the performance of gifted and nongifted sixth graders and high school students on verbal analogy problems. In this study, the gifted students consistently scored higher on all cognitive tasks than the nongifted students. The results also demonstrated that the high school students had strategic and domain specific knowledge that was superior to the knowledge which the sixth graders possessed. In a study with similar results, Sheard and Readence (1988) found that college

students possessed more prior knowledge about the analogy vocabulary and concepts than did the eighth grade students.

A study conducted by Judy et al. (1988) examined the effects of two methods of instruction in solving verbal analogies on the performance of gifted and nongifted sixth grade students. The students were taught using either a method of direct instruction or an inquiry approach. Results demonstrated that the students who received the direct instruction outperformed the students who received the inquiry approach on the verbal analogy problems. The gifted students outperformed the nongifted students on all of the tasks.

Marr and Sternberg (1986) compared intellectually gifted and nongifted sixth, seventh, and eighth graders using a modified verbal analogy test. Each verbal analogy was preceded by known or new information about one of the analogy terms, and the subjects were told to solve the analogies as if this information were true. This experiment required the students to encode the information, decide if the information was relevant to the analogy task, and either apply or ignore the information while completing the task. The findings from this study revealed that the gifted students were more sensitive to the relevance of novel information than the nongifted students. More relevant to the present study was the finding that the gifted students outperformed their nongifted peers on the verbal analogy task. These results

corroborated the results from other studies which involved a comparison between gifted students and their nongifted peers.

Since classroom teachers are faced with the difficult task of instructing children with many different ability levels, research studies have also been conducted to examine the analogical reasoning ability of both language impaired and learning disabled students. There are an ever increasing number of students being classified in these two categories in the public schools today. Thus, it is important for information to be available to classroom teachers concerning the development of higher level cognitive abilities in these students. The following two sections of the present research study summarize the information which is available today on the development of analogical reasoning ability in language impaired and learning disabled students.

Language Impaired Students

Two research studies compared language impaired students with normal language ability peers on an analogical reasoning task. These students were considered to be language impaired because they had normal intelligence but deficits in language comprehension. A child with a language deficit would seem to be at a disadvantage when he is required to solve problems which involve words and their meanings or problems which are presented in a verbal format. Thus, a language impaired

student might be expected to have trouble completing analogical reasoning tasks.

Kamhi et al. (1990) conducted an experiment which measured the performance of six to eight year old children on an analogical acquisition and transfer task. The problems were presented to the students in both a verbal condition and a modeling condition. The only differences between the language impaired students and their normal ability peers were found with the language impaired students in the verbal condition. This group of students took significantly longer to acquire the problem solutions. Once these students acquired the problem solution, they were able to use this information to solve an analogous problem. These results indicated that the language impaired students were at a disadvantage when information was presented verbally because these students may take longer to decode and understand this information.

Nippold et al. (1988) also conducted an experiment to examine the analogical reasoning abilities of language impaired students. These students, age six to eight, were compared with normal ability children on a verbal analogical reasoning task. In this study, the normal ability students outperformed the language impaired group of students on the verbal analogy task. However, when the intelligence factor was controlled statistically, the differences between the two groups of students on the reasoning task were eliminated.

This indicated that intelligence played a major role in the children's ability to complete the analogical reasoning task. This study also supported the thesis that there is a strong relationship between verbal analogical reasoning and perceptual analogical reasoning.

Language impaired students might be at a disadvantage on an intelligence test because of the verbal format of many intelligence tests. The background knowledge a student has gained also has an impact on the student's ability to score well on an intelligence test. Since much of the information from our world comes to us through either verbal or written language, a language impaired student may not be able to process this type of information as well as a normal language ability student. These factors would put language impaired students at risk to score poorly on both intelligence tests and analogical reasoning tasks. Because of the fact that Nippold et al. found a strong relationship between verbal analogical reasoning and perceptual analogical reasoning, students having trouble with one type of analogy tasks might have trouble with other types of analogies, also.

Learning Disabled Students

Another type of student who might be at a disadvantage on verbal reasoning activities is the learning disabled student. Reed (1987) conducted a study to determine how

learning disabled students' performance on verbal and nonverbal analogies compared with the performance of their normal achieving peers. Sternberg's componential model of analogical reasoning was employed to compare differences in the procedures used by students while solving verbal and nonverbal analogies. Results showed that the learning disabled students were not as accurate as their normal achieving peers on the verbal analogies. The learning disabled students did not display a greater reliance on associative responding or strategy differences from their normal achieving peers.

The purpose of a 1986 study by Simmons was to compare the analogical reasoning abilities of learning disabled and normal achieving students. The performance of the ten and twelve year old students was compared on a verbal analogy task. Results indicated that the performance of the learning disabled students on the verbal analogy task was significantly lower when compared to the performance of the normal achieving students. The learning disabled students also had difficulty producing spontaneous solutions to the verbal analogy problems.

Since the majority of the students identified as learning disabled are also poor readers (Harris and Sipay, 1985), weaknesses found in many reading disabled students are evident in learning disabled students as well. These weaknesses may include cognitive deficits, difficulty with printed language,

verbal memory deficits, and limitations at the lexical level. All of these cognitive skills are related to a student's ability to complete verbal analogy problems. Thus, it is not surprising that learning disabled students do not score as well when competing with normal ability students on this type of task.

Teachers must become cognizant of how students with different potentials develop the ability to reason by analogy. Educational researchers are finding more effective methods of incorporating analogies into the classroom and more ways to use analogies. The fact that analogies come with a built in context makes them especially useful as a means of increasing a student's awareness and knowledge of the world around him.

ANALOGY IN THE CLASSROOM

Acquisition of Knowledge

Vosniadou and Schommer (1988) conducted a study to determine whether young children were able to benefit from explanatory analogies provided to help them acquire information from expository text. In this study, the children, aged five to seven, listened to four descriptive texts with and without explanatory analogies. The children were then asked inferential questions about the texts and asked to recall information from the texts. Results of this

study demonstrated that using explanatory analogies with young children increased the amount of information the children retained from the text. The children recalled more information from expository texts with analogies than from similar texts without analogies. The researchers theorized that the use of analogies helped the children construct more complex representations of the concepts from the text. This, in turn, facilitated the children's recall of information from the text.

A 1985 study by Bean et al., which was carried out with high school students, found similar results. Two study guides, one with analogies and one without analogies, were used in a high school biology class. In the analogical study guide, the structure and function of a human cell were compared to the various parts of a factory. Results indicated that the analogical study guide was the most effective for students whose comprehension scores were below 70% on previous class tests. These study guides proved useful to students who were having trouble understanding and assimilating the information from the biology text, but were unnecessary for students who were able to absorb the information on their own. A study by Burns (1984) also found superior results using an analogy based instruction over traditional instruction in a high school biology class.

A study by Gilbert (1985) found very different results from those in the Bean et al. and Burns' studies. Gilbert

constructed two study units, one with and one without analogies, from a high school biology text. No differences were found in the performances of the two groups of students on multiple choice or essay questions from the texts.

The purpose of a 1983 study by Vosniadou and Ortony was to investigate whether first and third grade students could use an analogy to facilitate their acquisition of new information from a text. The students listened to two passages containing the same factual information. One passage contained an analogy to help the students retain more information from the text and the other passage did not. After listening to the passage twice, the students were asked both factual and inferential questions about the material. The findings from this study demonstrated that the children recalled more information and answered more questions correctly about material containing the analogies. The researchers theorized that the analogies may have helped the students construct a new domain, composed of prior knowledge and the new information from the text. Because this new domain was composed of both old and new information, the information may have been easier for the students to recall.

Schustack and Anderson (1979) conducted two experiments to determine whether analogies could be used to help students improve their memory. The experiments were designed to provide information about how prior knowledge affects the acquisition of new information. Results from these

experiments suggested that analogies improved the students' ability to remember information because of the more elaborate processing they required. Processing the analogy along with the prior knowledge formed a more elaborate memory trace than processing without the prior knowledge. The subject's ability to remember information improved because of the more elaborate memory trace which resulted.

F.C. Bartlett, in his classic book Remembering (1932), wrote, "it is fitting to speak of every human cognitive reaction-perceiving, imaging, remembering, thinking, and reasoning-as an effort after meaning. We have seen that in perceiving, the data presented have to be actively connected with something else before they can be assimilated" (p. 44). "Remembering is thus only one special form of the general problem of meaning, and occurs when the setting of a particular group of stimuli are treated and described as belonging to the past life of the remembering subject. In recall the reactions to the immediate stimuli are treated as having their 'fitting' termination in the reconstruction of 'schemata' and organized settings and materials of earlier date" (p. 237). In the context of a classroom, the analogy could be the means of making the connection between the prior knowledge and the present concept or situation in order that the data might be assimilated.

However, a clue must be provided by either the subject or the task so that the prior knowledge is accessed. This is

one of the limitations in using analogies. The results of experiments with analogies have demonstrated repeatedly that subjects often do not perceive that one situation or concept is analogous to another. Thus, it is impossible to use an analogy to facilitate the acquisition of knowledge or the recall of information from the situation. In the mind, a potential analogy may be stored in a very different context from that in which the target concept is located. The problem of how relevant analogies are noticed is closely related to the issue of how analogies are accessed in memory (Gick and Holyoak, 1980).

A 1982 study by Hayes and Tierney investigated the function of the analogy when new information is introduced to readers using an analogy. Three possible functions of the analogy were considered: to activate specific analogous information, to activate generally related knowledge, or to provide information which readers could use to construct their own comparisons. In this study, high school students endeavored to learn about cricket (the British game), which was considered to be an unfamiliar topic. The analogous passages provided a comparison between playing cricket and playing baseball. Results of the study indicated support for all three of the functions of the analogous material, with the greatest support for the general knowledge activation function. Students performed better on written recall tasks, prediction tasks, and discrimination tasks when they were

given information about the unfamiliar topic. Hayes and Tierney theorized that the data provided support for a schema theory of comprehension and knowledge acquisition. The analogous text was helpful in some situations, especially for groups with disparate levels of prior knowledge. Bean et al. (1985) also found that analogical study guides were more useful in classes where there were students with a wide range of abilities and amounts of background knowledge.

According to Bartlett, (1932), "'schema' refers to an active organization of past experiences, which must always be supposed to be operating in any well-adapted organic response. All incoming impulses of a certain kind, or mode, go together to build up an active, organized setting. Condensation, elaboration, and invention are common features of ordinary remembering, and these all very often involve the mingling of materials belonging originally to different 'schemata'. A new incoming impulse must become a stimulus which enables us to go directly to that portion of the organized setting of past responses which is most relevant to the needs of the moment" (p. 201). It would seem logical to assume that the more elaborate the schemata is, the more easy it would be to access. One advantage to using analogies in learning situations is that an analogy may cause the learner to form a more elaborate memory trace because of the contextual information that the analogy contains.

Using Analogy to Decode Words

Reading is the process of constructing meaning from the text. This interactive view of reading emphasizes the fact that reading is more than decoding abilities and a set of isolated skills. The reader does not extract meaning from the text; rather, he constructs meaning from the text and from information in his mind. The text that is constructed depends on the reader's strategies, background knowledge, and purpose for reading. The resulting text is constructed when the reader makes inferences and elaborations by integrating his prior knowledge with the text that he is reading (Beck, 1989; Paris and Oka, 1989; O'Brien et al., 1988).

Skilled reading is a combination of many cognitive, perceptual, and linguistic processes. Each of these processes is not only important because of the part it plays in the reading act, but also in the effect it has on the other processes which are involved. Thus, deficiencies in any one process may have a profound impact on the reader's ability to construct meaning from the text (Spiro et al., 1980). Two of the most important processes which must be developed before a child can become a proficient reader are the ability to decode words and the ability to comprehend what is read.

Students who are able to make analogies between the orthographic patterns of words can apply this skill to decode new words. Goswami (1990) conducted a study to determine

whether children decode unknown words by using an analogy strategy or through the use of phonological priming. Phonological priming refers to the preparation of a certain pronunciation over all the others by the use of an auditory or visual cue. The two experiments were conducted with groups of six to nine year old students with a reading age of six. Results of the experiments demonstrated that the role of phonological priming in an orthographic analogy was minimal. Phonological priming was found only in single word tasks and seemed to have no role in reading the unknown words which were embedded in stories. Goswami theorized that beginning readers may use an analogy strategy to decode unknown words but phonological priming does not sufficiently explain the analogy effect in decoding the unknown words. The study also showed that analogies could occur between parts of words as well as between whole words.

Goswami (1986) conducted another study which examined whether kindergarten, first, and second grade students would use an analogy strategy spontaneously to decode unknown words. The children played a word game in which they had to read real and nonsense words, most of which were analogous to a clue word. The clue word was always present, but no instruction was given about using this clue word. Findings from this study indicated that children from both reading levels (first and second) made analogies between the beginnings and endings of words for both real words and nonsense words. Even the

children who were nonreaders (kindergarten) were able to make analogies between the ends of words.

The purpose of a study by Manis et al. (1986) was to investigate the use of two decoding strategies: an analogy strategy and a strategy based on spelling-sound correspondence rules. The subjects in this study were fifth and sixth grade dyslexic and normal readers as well as a group of younger normal readers who were matched by reading age with the dyslexic readers. The students were asked to pronounce nonsense words, which were constructed to differentiate between the two strategies. The results of this study demonstrated that dyslexic students generated fewer analogy responses than either normal readers of the same age or younger readers of an equivalent reading ability. The researchers theorized that the decoding difficulties often found in dyslexic readers may be the result of qualitatively different patterns of strategy use between the two groups of students.

A 1985 study by Wolff et al. (1985) examined which type of instructional strategy students would use to decode unknown words. The subjects in the study were normal achieving second and fifth graders as well as learning disabled fifth graders. Often, analogy strategies are not used automatically by learning disabled students. These strategies are usually not taught systematically to this group of students, either. An analysis of the strategies used indicated that the disabled

readers employed strategies similar to those of the younger students. The analogy strategies were used most often by the normal achieving fifth grade students. However, when the learning disabled students received direct instruction in the use of an analogy strategy to decode unknown words, they were able to use the strategy successfully. The researchers felt that the analogies were a powerful strategy in word identification which should be taught systematically to learning disabled students. This study, as well as several studies mentioned earlier (Judy et al., 1988; Alexander et al., 1986; White and Alexander, 1984), found that the direct instruction method was the most successful means of teaching students to use analogy in the classroom.

Baron (1979) conducted a study to determine which type of strategy students would use to decode unknown words. The strategies which were investigated were an orthographic mechanism using spelling-sound correspondence rules and a word-specific association strategy. The researchers were also searching for spontaneous reports of the use of an analogy strategy. One group of fourth grade students were instructed in an analogy strategy. Results of the experiments provided evidence that both rules and specific associations are used to read regular words. The students who received the analogy instruction pronounced more of the nonsense words correctly than did the students who did not receive the training. There were frequent instances of the use of an analogy strategy in

finding parts of known words embedded in the nonsense words. The ease with which the analogy strategy was used by the students indicated to the researchers that the mechanism for this strategy was already available to the students before they received the training.

Marsh (1977) conducted a study to determine whether the strategies used to pronounce unfamiliar words changed as a result of the developmental level of the students using the strategies. The students in this experiment were in grades five and eleven as well as a group of college students. A strategy which used grapheme-phoneme correspondence and an analogy strategy were examined. The students were asked to pronounce nonsense words which were constructed so that the strategy being used could be determined by the pronunciations of the words. Findings from this study revealed developmental changes in the strategies used to read unknown words. The younger children's main strategy was a grapheme-phoneme correspondence strategy, but the principal strategy of the college students was an analogy strategy. The researchers theorized that the analogy strategy largely replaced the grapheme-phoneme strategy by the time the students were of college age.

A direct instruction method was employed to teach normal achieving and learning disabled students to use an analogy strategy to decode unknown words. Results from this study by Wolff (1980) demonstrated that analogy strategies can be

taught to elementary school age learning disabled students. Differences in the use of the analogy strategy suggested a developmental trend in the reading strategies utilized by the students. Wolff recommended direct instruction in analogy strategies as a word recognition tool in every beginning reading program. The results from previous studies in this review also provide evidence that an analogy strategy is a very effective means of improving students' ability to decode unknown words.

A similar strategy can help students spell words correctly by identifying similar orthographic patterns between known and unknown words. A study by Englert et al. (1985) examined the effects of a direct instruction method based on an analogy strategy to help mildly handicapped students spell new words. Spelling patterns from familiar words were used to spell the new words. Mildly handicapped students often have trouble recognizing word patterns and then applying these patterns when spelling new words. The results of this study showed an improvement in the spelling ability of mildly handicapped students who were taught the analogy strategy. Instructional methods for these students, which included the direct instruction of a spelling strategy and the means of generalizing the word patterns to the unknown words, were effective with this type of student. Here again, the direct instruction method was proven to be the most effective

means of training students of below average ability in the use of an analogy strategy.

Analogy as a Comprehension Strategy

Another study which used a direct instruction method to teach the students was conducted by Alexander et al. (1983). This study was concerned with improving the comprehension abilities of fourth and sixth grade students through the use of training in analogical reasoning. The findings from this study revealed that the students were able to improve their ability to solve analogy problems after direct instruction in the component processes of analogical reasoning (Sternberg, 1977). However, these students did not show any improvement in their ability to answer inferential questions on a reading comprehension test.

The study which Judy et al. (1988) conducted with gifted and nongifted sixth grade students was also interested in whether direct instruction in solving analogy problems would transfer to a reading comprehension task. A major contribution from this study was the finding that training in solving analogy problems could transfer to a reading comprehension task. These results are in contrast to the results from the study by Alexander et al. (1983) which did not show any transfer from the analogy training to the comprehension task.

A 1984 series of experiments by Simons examined the use of analogy in the comprehension of expository text. Simons' experiments were conducted with subjects from elementary and secondary schools as well as college students. The analogies were used with students who were studying biology, science, psychology, and computer programming. Results indicated that the use of concrete analogies improved the performance of students in these four different subjects. Students studying with the analogies scored higher on a reading comprehension test than did students studying without the analogies. However, it took the students longer to read the material which contained the analogies. Results also showed that learning with analogies provided the students with a better understanding of the relations between the concepts. One experiment demonstrated that elementary school students could even benefit from analogies which were presented orally. Simons proposed that analogies were only useful as a reading aid when there was a sufficient amount of time for the students to read the analogies and compare them with the concepts from the text. A study by Rider (1980) provided further evidence for the effectiveness of analogy as a means of improving a student's ability to comprehend material. This study found an increase in the reading comprehension scores of high school students who received training in solving verbal analogy problems.

The purpose of a 1987 study by Silkebakken was to determine the effect of student generated analogies on the reading performance of sixth grade students. The analogy instruction included six weeks of direct instruction in classifying and self-generating analogies. Results indicated that the group of students which received the analogy based instruction scored significantly higher on both a vocabulary-comprehension test and on a verbal analogy test. A strong correlation was found between the analogical reasoning scores and the vocabulary-comprehension test scores. A study by Wong (1990) also demonstrated the usefulness of generative analogies. The results from the Wong study indicated that information could be constructed, rather than transferred, through the use of generative analogies.

SUMMARY OF RESEARCH RESULTS

The analogical reasoning process has been the focus of a great deal of scrutiny, especially during the past thirty years. Earlier studies were interested in whether the ability to reason by analogy, and intelligence as measured on mental ability tests, were related. Findings from these studies almost unanimously provided evidence that there was a close relationship between these two cognitive abilities. Researchers examined whether the ability to reason by analogy was a skill which improved throughout the elementary and

secondary school years or one which developed much later. Most came to the conclusion that this ability did, indeed, develop as the students progressed through their elementary school years. Educators were interested in knowing if the ability to reason by analogy was a skill that could be taught to students of different ages and ability levels. Research indicated that the ability to reason by analogy could be developed in most students, from preschool to college, and to students of many different ability levels.

Educators were also interested in how analogy could be used in their classrooms. Research results provided evidence that analogy was a very useful tool for almost every classroom. Analogy was found to be a useful retrieval cue as well as a means of building schema in students. Since analogies provide a context in which new information can be assimilated, students are encouraged to integrate this new information. This restructuring of schemata provides the learner with a more distinctive memory trace, which may be called to mind more easily than a single schema. Analogies may help students focus on the core of what is important in a concept or a situation. The students learn to ignore surface differences and similarities in a situation while concentrating on the underlying relationships.

The analogical reasoning process itself was examined and broken down into its component processes. These processes were analyzed in order to determine if any one of them was

more important than the others. Much of the information derived from these studies was in the form of theories rather than concrete evidence. At the present time, these theories are our only means of attempting to explain the results of the research studies as well as to understand how analogies facilitate our comprehension of new situations and concepts.

Most relevant to the present study were the experiments that were interested in analogical reasoning as it relates to the reading process. Numerous research studies examined analogical reasoning as it relates to vocabulary development. Findings from these studies indicated that students were able to make analogies between the orthographic patterns of words and apply this information to decode new words. Less clear is the relationship between the ability to reason by analogy and the ability to comprehend written material. Several studies found that training in analogical reasoning improved a student's ability to read and comprehend text. However, a study by Alexander et al. (1983) did not find any improvement in the students' ability to read and answer questions about a text after they had received training in solving analogy problems. Alexander et al. theorized that a three day training period was not a long enough period of time to expect to see a change in a student's comprehension abilities, which is a valid observation. If a clear connection could be proven between reading comprehension and training in reasoning by analogy, this would be very useful knowledge for teachers who

work with children who are having problems understanding what they read.

Disabled readers make up a small, but ever expanding group of the elementary and secondary school population. Their futures are influenced by their ability to develop higher level thinking processes, of which analogical reasoning plays a vital role. Their ability to succeed at analogical reasoning problems may affect their scores on reading tests, intelligence tests, and predictive tests of college success such as the SAT. These scores, in turn, have a major influence on the students' success in school and their choice of a career.

It is imperative with today's emphasis on test scores as a determination of acceptance or rejection in academic programs, that we learn as much as possible about the development of analogical reasoning abilities in disabled readers. Research up to the present contains little information about the development of higher level cognitive abilities in this group of students. Considering the vital role that analogical reasoning plays in learning, it is important that we gain more knowledge in this area. It is felt that the present research study will provide information about both the development of analogical reasoning abilities in disabled readers and a method teachers can use to improve the analogical reasoning ability of their students.

CHAPTER III

MEASURING INSTRUMENTS AND PROCEDURES OF THE STUDY

INTRODUCTION

This chapter provides information concerning the subjects, measuring instruments, data analysis procedures, specific procedures, and collection of data for the present study. Since this study contained elements of both descriptive and correlational research, it was regarded as a descriptive correlational study. The data collection for the first research question used descriptive research methods, which included direct observation and audio taping. Data collection for the remaining four questions involved the use of correlational research methods. These methods included the comparison of quantitative data in order to determine the relationship between several pairs of variables. Using several different methods to collect data should provide a more complete picture of the analogical reasoning processes of these reading disabled students.

SUBJECTS

According to Gay (1987), a minimum acceptable sample size for a correlational study is 30 subjects. The present study

contained just 30 subjects. No attempt was made to obtain a random sample for this study. Instead, the entire population of students at the Reading Center during the spring, 1989 semester was used. Thirty-eight subjects were tested, but only 30 remained in the study because one of the subjects did not attend an acceptable number of instructional sessions and seven other students did not fit the criteria for reading disabled students according to the Harris and Sipay procedure.

Alexander and Heathington (1988) stated that almost three times as many males as females are found in remedial and corrective reading programs. The most reasonable hypothesis for this gender difference is the fact that our culture has very different expectations for males and females. The attitudes and behaviors of teachers and parents in our culture may encourage the development of reading skills in females more than it does in males. The gender ratio of the students in the present study was 66% male and 34% female, which is much higher than the population ratio of males to females in the school system.

Although several of the students were from middle class homes, most came from a lower socioeconomic status family. The UT Reading Center might attract many low income families because of its reduced fee schedule. However, a large proportion of children with reading problems come from low SES families (Harris and Sipay, 1985). Another consideration is the fact that many of these children were minority children.

Minority children as a whole read below national levels, so it might be expected that there would be a disproportionate number of minority students in attendance at the Reading Center. This was, in fact, the case during the spring, 1989 semester. According to the Knox County Department of Public Instruction, the 1988-89 minority population of the Knox County Schools was 13%. The majority of the students that semester were from Knox County schools, although a few were from nearby counties. The minority population at the Reading Center that semester was 31%, which is a much larger percent than the 13% minority population in the Knox County School system.

The age of the students ranged from seven to twelve, with a grade level span from the first through the seventh grade. There was one first grade student (who was eight years old), and two seventh grade students. The largest single group was the second grade, with eleven students. The number of students in each group from grades three through six was very similar.

MEASURING INSTRUMENTS

The appropriateness of the instruments used to measure the variables in a research study has an influence on the results of that study. The reliability and validity of the measuring instruments are also important considerations. If

incorrect data are collected, the correlation coefficient which is obtained will be an inaccurate measure of the relationship between the variables (Gay, 1987). The measuring instruments which were used in the present study are presented along with the reasons why each instrument was chosen.

Gates MacGinitie Reading Tests

The Gates MacGinitie Reading Tests are norm-referenced, group reading tests which contain vocabulary and comprehension subtests. The vocabulary test words are presented in a brief context phrase, which was written to suggest the part of speech but not the meaning of the word. This was done to ensure that the test would measure word knowledge and not the student's ability to use context clues to figure out the meaning of the word. In levels one and two, the comprehension passages were chosen to relate to the interest and knowledge of beginning readers. For the upper levels, the passages were chosen from a variety of published materials that students were likely to read for school assignments or recreational reading. Both literal and inferential questions were included with each text. Passages were chosen so that males and females from many ethnic groups would be represented in the content of the text.

There are nine levels of the tests, with each level having at least two equivalent forms. The Buros' Mental

Measurements Yearbook states that these tests function well as a measure of students' reading ability for evaluation purposes and for use in research. A reading test is valid to the extent that it measures the knowledge and skills the schools want the students to learn from their reading instruction. A number of steps were taken to assure that the Gates MacGinitie Reading Tests would be valid for most school reading programs. The validity of the test is discussed in the teacher's manual and guidelines are provided so that teachers may assess the validity of the tests in specific situations. According to the review in Buros and the information in the teacher's manual, the reliability of the total test scores is between .93 and .95. Scores on these tests can be reported as national stanines, percentile ranks, normal curve equivalents, scaled scores, and grade equivalents. The scores which were used for the present study were presented in the form of grade equivalents.

Slosson Intelligence Test (SIT)

The SIT is an individual screening intelligence test which is used as a means of evaluating a subject's mental ability. It is inexpensive and easy to administer in a short period of time. The test, which contains 194 short answer questions and observations, is considered appropriate for subjects from two weeks to 27 years. It is intended to be a

shortened form of the Stanford-Binet Intelligence Test (SB), and the correlations between the two tests are in the mid-.90's. According to the information in the manual, the SIT satisfies all the requirements to be considered a parallel form of the SB. This means that IQ's or standard deviations from both instruments do not differ significantly. Because of questions concerning the reliability and validity of the SIT, the best use of this test, according to Buros, is as a means of estimating SB IQ's.

In the present study, the SIT was used to provide an estimate of each student's mental ability. The manual for the SIT states, and the researcher concurs, that intelligence test scores are an approximate estimate of a subject's ability and not an exact measure of ability. The scores on this test are reported as mental ages, intelligence quotients, percentile ranks, normal curve equivalents, and stanines. The scores which were used for the present study were in the form of stanines, mental ages, and intelligence quotients.

Peabody Picture Vocabulary Test-Revised (PPVT-R)

The PPVT-R is an individually administered, norm-referenced test of receptive vocabulary. It does not require subjects to read or write, which makes the test especially appropriate for non-readers as well as other subjects with written language difficulties. The PPVT-R contains 350 items

which are presented in groups of four pictures. The subject is asked to identify the picture which corresponds to a stimulus word read aloud by the examiner. The test is appropriate for use with subjects from two years six months to 40 years. The validity evidence for the tests, according to Buros, supports the content, construct, and concurrent validity of this test. The manual provides information concerning content validity, construct validity, and criterion related validity. However, the validity data which is provided is from the PPVT and not the PPVT-R. Correlation studies between the PPVT-R and the PPVT show a median correlation of .70. Based on this correlation, the manual states that the validation data which was obtained for the PPVT can also be considered to be appropriate for the PPVT-R. The content validity was built into the test when a complete search was made for all the words whose meanings could be depicted by a picture. The test was constructed so that it retained a good cross section of the initial list of words. According to the manual, as long as the PPVT-R is viewed as a test of hearing vocabulary, its rational validity rests on its content validity. The manual discusses the PPVT-R's correlation with intelligence tests, vocabulary tests, and achievement tests. Information which was obtained from other sources, such as Buros, ERIC, and doctoral dissertations, is also included in the manual.

The reliability of this test has been established. Two types of reliability coefficients, internal consistency (split-half) and alternate forms, are reported in the manual. The reliability coefficient for the internal consistency is near .81, and the alternate forms reliability coefficient (median) is .79. The raw scores on the PPVT-R may be converted to either deviation type age norms such as standard score equivalents, percentile ranks, and stanines or to developmental type age norms such as age equivalents. The scores which were used in the present study were stanine scores.

The PPVT-R was used in two other research studies on analogical reasoning. Nippold and Sullivan (1987) used this test as a means of selecting students who had normal language comprehension. White and Alexander (1984) used the PPVT-R to determine the vocabulary knowledge of the subjects in their study. The researcher felt that this test was an appropriate test to use in the present study as a means of assessing the receptive vocabulary of the students.

Woodcock Reading Mastery Tests-Revised (WRMT-R)

The WRMT-R is a comprehensive battery of tests which measure several important aspects of reading ability. The word comprehension section of the test contains a 79 item analogy subsection, whose items are arranged in order of

difficulty. Norms are provided for students from grade levels K through college senior. The manual contains information concerning the norming procedures used with the WRMT-R as well as the reliability and content validity of the test.

The WRMT-R was used as a measure of analogical reasoning ability in two of the research studies cited earlier in this paper. Alexander et al. (1983) used the analogy section of the WRMT-R as a means of assessing the analogy ability of the fourth and sixth grade students in their study. Judy et al. (1988) used the WRMT-R as a direct measure of the analogy performance of the gifted and non-gifted students in their study.

The WRMT-R was designed to be administered individually to each student. According to the directions, the students are to read the A, B, and C terms of the analogy and then provide the D term. The examiner is not to read any item aloud. In the present study, these instructions were not followed. If the students were required to read the words in the analogies, their ability to solve the analogy problems would depend, at least in part, on their ability to read the words. Since the purpose of the test was to assess the students' ability to complete verbal analogy problems, and not to assess their reading ability, the analogies were read orally to the students. The students were required to write a single word answer to complete the analogy. As long as the examiner was able to determine which word the student wrote,

the spelling of the words was not taken into account when the tests were scored. If the examiner was unable to decipher the word, the student was asked to provide the answer orally at the time of the testing. The tests were administered to the students in a group setting during the regular instructional session.

Harris and Sipay Procedure

Harris and Sipay (1985) have recommended a procedure for identifying students with a reading disability. This procedure contains formulas to compute a Reading Expectancy Age, a Reading Expectancy Quotient, and a Reading Quotient. Several factors, such as intelligence, vocabulary skills, linguistic competence, and background knowledge have an influence on a student's progress in reading. The Harris and Sipay procedure takes these factors into account when computing the reading expectancy age.

READING EXPECTANCY AGE (R EXP A) The reading expectancy age is a means of determining a student's reading potential. In reading expectancy formulas, variables that are related to reading achievement, such as years in school, chronological age (CA) and mental age (MA), as well as a constant number, are used to determine a student's reading potential. Several different formulas, each with its own variables, are

available. The Harris and Sipay formula was chosen for the present study because it is considered to be the most reliable. There is very little research concerning the measure of reading disabilities, but the two studies that are available found that the Harris and Sipay procedure was the preferred formula (Dore-Boyce et al., 1975; Honel, 1973). This formula gives priority to the importance of intelligence but acknowledges the importance of general maturing by giving mental age twice the weight of chronological age. The formula is:

$$\text{Reading Expectancy Age} = \frac{2MA + CA}{3}$$

3

This formula is considered to be appropriate for use with students from eight to fourteen years of age.

READING EXPECTANCY QUOTIENT (R EXP Q) A Reading Expectancy Quotient shows how a student's present reading level compares with his expected reading level. Reading Expectancy Quotients that fall between 90 and 110 are considered to be normal. A Reading Expectancy Quotient below 90 indicates that the student is not reading up to expectancy and that there is a strong likelihood of a reading disability. The formula is:

$$\text{Reading Expectancy Quotient} = \frac{RA}{R \text{ Exp } A} \times 100$$

R Exp A

The lower the Quotient, the more severe the disability is considered to be.

RA stands for Reading Age. Since the Gates MacGinitie Reading Tests provide a grade equivalent score, this score was changed into a RA. Harris and Sipay stated that there tends to be a difference of 5.2 years between chronological age and grade placement. They recommended changing grade equivalent scores into reading age scores by adding 5.2 years. This was done in the present study for the purpose of computing the Reading Expectancy Quotient and the Reading Quotient.

READING QUOTIENT (RQ) The Reading Quotient compares a student's reading level with that of other students of the same chronological age. The formula is:

$$\text{Reading Quotient} = \frac{\text{RA}}{\text{CA}} \times 100$$

Both the RQ and the R Exp Q formulas multiply the answer by 100 in order to eliminate the decimal point.

The Reading Quotient, along with the Reading Expectancy Quotient, are used to distinguish between disabled readers, underachievers, and slow learners. A disabled reader is a student who is reading significantly below his expectancy level and the average performance of his peers. These students have both a R Exp Q. and a RQ below 90.

Students whose R Exp Q. is below 90 but whose RQ is above 90 are not making full use of their above average potential. These students are usually able to succeed with their reading assignments in school and they also have a high potential for improving their reading abilities. These students are described as underachievers.

The students whose R Exp Q is 90 or above but whose RQ is below 90, are reading about as well as can be expected when their limited potential is taken into account. These students, referred to as slow learners, might be having trouble completing their school assignments and would be less likely to be able to improve their reading abilities. Table 1 shows how these students were classified.

TABLE 1

Distinguishing between disabled readers, underachievers, and slow learners.

*Classification	R Exp Q	RQ
Normal reader	90 or above	90 or above
Disabled reader	below 90	below 90
Underachiever	below 90	90 or above
Slow learner	90 or above	below 90

*Harris & Sipay, (1985) p. 155.

In the present study, each child's reading expectancy score was compared with his actual reading level (as measured on the Gates MacGinitie Reading Tests) to determine the severity of his reading disability.

DATA ANALYSIS PROCEDURES

Data Collection for Question One

The first question examined whether reading disabled students were able to develop or improve their ability to reason by analogy. Descriptive research methods were used to gather data for the first research question in the present study. The specific procedure used to collect the data was participant observation. The researcher was a participant in the classroom situation which was being described as well as the teacher in all of the testing and instructional sessions. Data were collected from the students prior to, during, and after the instructional sessions. Three other instructors in the Reading Center during that semester served as assistants for the testing and computer sessions. To assure that the data collection be as objective as possible, all instructional sessions were audio taped. Through the audio tapes, it was possible to determine which students answered certain analogy questions, whether a student received any help while figuring out the answer to an analogy, and, based on self-reporting,

what the student was thinking as he completed the analogy problems.

Levinson and Carpenter (1974) required the 9, 12, and 15 year old subjects in their study to provide explanations for their responses to the verbal analogy problems. Goldman et al. (1982) concluded that what students say when they justify their answer choices estimates their thinking about why the responses are correct. Ericsson and Simon (1984) concluded that verbal reports are a "rich source of data that can be of the greatest value in providing a full account of cognitive processes" (p. 373). In the present study the student justifications were used as a means of understanding how the students arrived at their responses.

Each student's posttest score on the WRMT-R was used to show the student's ability to answer verbal analogy problems. This, in turn, was assumed to be a valid indication of the student's analogical reasoning ability. The researcher felt that this assumption could be justified because of several factors. Reasoning by analogy is defined as the ability to discover relationships between concepts or situations which may not seem similar. Verbal analogy problems require the student to do just that: find a relationship between pairs of words (concepts) which might seem unrelated on the surface. By reading the analogy problems to the students, the test remained a measure of the student's ability to reason by analogy and not merely a vocabulary test.

Another factor was the finding that several research studies have demonstrated a statistical correlation between a subject's ability to solve different types of analogy problems. Nippold et al. (1988) found that verbal proportional analogical reasoning was significantly correlated to perceptual proportional analogical reasoning and also to functional analogical reasoning. Nippold and Sullivan (1987) found that perceptual analogical reasoning was statistically related to verbal analogical reasoning. A study by Sternberg (1977) demonstrated that analogies which appear quite different on the surface (verbal, geometric, and people piece) may be solved basically the same way. These studies could all be an indication that the ability to reason by analogy is a comprehensive skill which is made up of many subskills, such as the ability to complete perceptual analogy problems or the ability to complete functional analogy problems.

Many researchers who are examining the analogical reasoning process have based their research on the premise that performance on verbal analogy problems is an indication of a person's ability to reason by analogy (Judy et al., 1988; Alexander et al., 1987; Nippold and Sullivan, 1987; Sternberg and Nigro, 1980; Sternberg and Rifkin, 1979). Sternberg (1986) stated, (verbal analogy) "problems are frequently used to measure reasoning skill and can provide quite good measures of it" (p. 309). Sternberg used his unified theory of human reasoning to distinguish reasoning tasks from nonreasoning

tasks. He believed that verbal analogies could be classified as inductive reasoning tasks because they required the "controlled and mediated use of inferential rules for purposes of selective comparison and selective encoding" (p. 296). Alexander et al. (1987) pointed out, "the solution of analogy problems can be explained on the basis of the componential model of analogical reasoning as described by Sternberg (1977)" (p. 402). The fact that verbal analogy problems can be solved while using a process based on the componential model of analogical reasoning is another indication that a person's ability to complete verbal analogy problems reflects his overall analogical reasoning ability.

On the other hand, several researchers who have completed studies to examine the analogical reasoning process do not believe that a proportional analogy is an adequate model for analogical reasoning. Gick and Holyoak (1983) point out that the concepts are presented to a subject in a proportional analogy, which is not the case in many situations where analogical reasoning ability is examined. A major reason why analogical reasoning is not used more frequently in problem solving situations is because the target analog is not recognized as being similar to the problem situation. Kamhi et al. (1990) stated, "performance on proportional analogies does not provide information about the factors that influence analogical reasoning and the actual processes involved in reasoning analogically" (p. 140).

In the present study, a student's performance on a proportional analogy task is not intended to provide a complete model of his ability to reason by analogy in all situations. It may, however, provide a general understanding of the student's overall analogical reasoning ability. Until more information is available concerning this question, it is difficult to draw any definitive conclusions. Based on these factors, it is assumed that a person's ability to complete verbal analogy problems is a reflection of his analogical reasoning ability.

Data Collection for Questions Two Through Five

Questions two through five were:

2. Is there a relationship between a reading disabled student's receptive vocabulary and his ability to solve analogy problems?
3. Is there a relationship between a reading disabled student's age and his ability to solve analogy problems?
4. Is there a relationship between a reading disabled student's general intelligence and his ability to solve analogy problems?
5. Is there a relationship between the severity of a student's reading disability and his ability to solve analogy problems?

Correlational research methods were used to collect data for questions two through five. The data were collected in order to determine whether, or to what degree, the different variables in the study were related. The degree of relationship between the two variables being examined was expressed as a correlation coefficient. If a relationship exists between the two variables, it means that scores within a certain range on one measure were associated with scores within a certain range on another measure (Gay, 1987). The variable being examined in the present study was analogical reasoning ability. The other variables which may be related to the analogical reasoning ability of a student were his age, his mental ability (as was measured on the SIT), his receptive vocabulary (as was measured on the PPVT-R), and the severity of his reading disability (as was computed using the Harris and Sipay procedure).

A correlation coefficient is a decimal number between +1.00 and -1.00 which demonstrates the degree of the relationship between two variables. If the coefficient is close to +1.00, the variables are positively correlated. This means that a student with a high score on one variable is likely to have a high score on the other variable. If the coefficient is close to -1.00, the variables are inversely related. This means that a student with a high score on one variable is likely to have a low score on the other variable. A significant correlation may suggest a cause-effect

relationship, but it does not establish one. However, it is possible to make predictions when the coefficient is close to either +1.00 or -1.00.

The method used in the present study to compute the correlation coefficient was the Pearson product moment correlation coefficient (Pearson r). The Pearson r is appropriate when the data from both variables are expressed as interval data. Since the Pearson r takes into account every score in both distributions, it is the most stable measure of correlation (Gay, 1987).

The paired measurements for the variables in questions two through five have been plotted on scatter diagrams. Each pair of measurements is represented by a point on the diagram. This provides a visual representation of the degree of relationship between the two variables. If the relationship is high, the points fall in a straight line. If the relationship is low (a coefficient close to .00) the points are randomly spread on the graph. The researcher felt that the scatter diagrams would provide a more vivid representation of the quantitative results of this study.

SPECIFIC PROCEDURES

Timetable for the Study

February, 1989

The Gates MacGinitie Reading Test was

administered to measure each student's reading level. (group test)

February, 1989

The Woodcock Reading Mastery Test-Revised (analogy section) was administered to measure each student's verbal analogy performance. (group test)

February,
March,
1989

The Peabody Picture Vocabulary Test-Revised was administered to measure each student's receptive vocabulary.
(individual test)

February,
March,
1989

The Slosson Intelligence Test was administered to measure each student's mental ability. (individual test)

February-
May, 1989

Each student received instruction twice week for at least ten minutes per session to improve his ability to complete verbal analogy problems.

May, 1989

The Woodcock Reading Mastery Test (analogy section) was administered to measure each student's verbal analogy performance. (group test) (different form)

May, 1989

The Gates MacGinitie Reading Test was administered to measure each student's reading level. (group test) (different form)

Instructional Method

The instruction in analogical reasoning was based on the componential theory of analogical reasoning theorized by Robert J. Sternberg (1977). This instructional method consists of four component processes: encoding, inferring, mapping, and application. In the first step, encoding, the student perceives the terms of the analogy and the relevant attributes of each term are stored in working memory. During the inference step, the student discovers the relationship between the first two terms of the analogy and stores this information in working memory. The mapping process consists of linking the first half of the analogy to the second half of the analogy by relating the first terms of each part. During the application process, the student discovers the two terms in the second half of the analogy which show the same relationship as the two terms in the first half of the analogy. An instructional procedure based on Sternberg's componential model of analogical reasoning was used in several other research studies as a means of developing or improving the analogical reasoning abilities of students (Alexander et

al., 1986; Judy et al., 1988; Loewenthal and Pons, 1987; White and Alexander, 1984).

All of the instructional sessions were conducted with a direct instruction method based on J. David Cooper's Steps of Direct Instruction (1986). The steps were:

1. The instructor discussed reasoning by analogy and the four step procedure of solving verbal analogy problems.
(the answer choices were provided).
2. The instructor modeled the four-step procedure for solving verbal analogy problems.
3. The students modeled the procedure and explained the reasoning behind their answer choices.
4. The instructor provided guided practice.
If the students were unable to complete the analogies, the instructor gave clues to them so that they could figure out the answers.
The procedure was retaught if necessary.
5. The students summarized the procedure and explained it in their own words.
6. The students practiced completing verbal analogy problems using step three.

7. The procedure was then applied to:

- A. Analogies with more difficult vocabulary levels
- B. Analogies with less obvious or more difficult relationships
- C. Analogies which required the students to generate the answers

A direct instruction method was chosen because several of the research studies cited previously have demonstrated its effectiveness in developing the analogical reasoning abilities of students (Judy et al., 1988; Loewenthan and Pons, 1987; Alexander et al., 1986; Wolff et al., 1985; White and Alexander, 1984).

The analogies were written on a large sheet of paper and placed on an easel in order that all students in the class would be able to see them. All analogy instruction and testing was conducted orally in order that the students' reading ability would not have an obvious effect on their ability to answer the analogies. Of course, a student's performance on any reasoning task is dependent, in part, on his background knowledge. A poor reader is at a severe disadvantage due to his lack of reading experience, because reading is one of the main ways a student gains background knowledge. In order for higher level thinking skills, such as reasoning by analogy, to develop, the student must have a

knowledge base of information about his environment and his world. Reading disabled students have often lost one of the most important means of developing this knowledge. However, this problem was not addressed in the present study; rather, it was accepted as a probable fact. In this study, the students were given the words in the analogy terms if they did not recognize them.

An attempt was made to determine the difficulty of each analogy, based on the vocabulary level of the words and the type of relationship between the terms of the analogy. Successful performance on a verbal analogy task does not necessarily indicate that the subject is using analogical reasoning abilities to solve the analogy problems. For example, the subject may have been solving the problems by using word associations instead of analogical reasoning. When the difficulty of a verbal analogy problem is controlled simply by manipulating the difficulty of the vocabulary words, the test becomes a vocabulary test rather than an analogy test. Students who score well on this type of test are exhibiting a high vocabulary level rather than an analogical reasoning ability. Thus, an effort was made in the present study to control the difficulty of the analogies by examining more than just the words themselves.

An effort was made to provide analogies that would be solved by reasoning rather than by word association. A word which was closely associated with one of the base terms of the

analogy was included in almost every forced answer choice problem. These closely associated words were often not the correct answer. In this way, the test was to be a measure of analogical reasoning ability and not a test of the student's ability to match words which were closely associated, such as cat:dog.

Willner (1964) pointed out that many analogy problems could only be solved if the subject possessed specific information about the concepts in the analogy. When this is the case, the problems then become information tests in an analogy format rather than a test of analogical reasoning ability. When the students do not know the meanings of the words in the verbal analogy problems, their chances of solving the problems correctly are substantially reduced. In the present study, when students were unable to answer the analogies because they did not know the meaning of the words, the meanings were provided for the students. This was an effort to ensure that the problems were not simply tests of general knowledge.

The instructional sessions started with easy analogies. The difficulty of the analogies increased in each class as the students became more proficient at solving the analogy problems. As the students became more familiar with the format of the instruction and more comfortable with providing justifications for their choices, their explanations often were quite brief. For example:

T. Try the last one for us.

St. Tree is to forest as fish is to ocean.

T. Why?

St. 'Cause there are trees in forests and fish in oceans.

Nippold (1986) found that students who were more competent reasoners were also better able to provide explanations for their answer choices. In the present study, as the students became more comfortable with providing the justifications for their answer choices, all were able to explain their choices satisfactorily.

In the instructional sessions where there were a wide range of ages and abilities, an attempt was made to provide analogies that were on an appropriate level for each of the students. Perhaps one sheet of analogies would be provided for a specific student if that was necessary in order for each student to be challenged. Almost every one of the students demonstrated an interest and enjoyment in completing the analogy problems. The students seemed to be challenged by the problems and eager to solve their own and each other's analogies. At times, two or three students provided the information that was necessary to solve the problems. The students did not find even a complex task such as reasoning by analogy to be an unpleasant task, at least not under these circumstances.

CHAPTER IV

FINDINGS

INTRODUCTION

The general purpose of the present study was to examine the analogical reasoning abilities of reading disabled students. The first research question was:

1. Are reading disabled students able to develop or improve the ability to reason by analogy?

The data for question one include examples of the analogy justifications from the audio tapes, which form the basis for many of the conclusions which were drawn. The audio tapes also provided information concerning many other aspects of the students' analogical reasoning abilities. The audio tapes demonstrated the usefulness of the instructional procedure the researcher recommended. There were many examples which illustrated specifically how analogies could be used as a diagnostic instrument or an instructional tool by classroom teachers. They provided information which explained why it is important to examine the analogies themselves before making a judgment about a student's ability to complete the analogies. At times, a closer examination of the analogies

would reveal that the problem was a vocabulary or an information task in an analogy format rather than a reasoning problem for a particular student.

After listening to the students' solutions of the verbal analogy problems and conducting the instructional sessions, a theory of analogical reasoning was proposed. The audio tapes provided not only a verbal record of the students' justifications but also a record of the time it took for the students to figure out the correspondences in the analogies. It was possible to categorize the mistakes the students made on the analogy problems, which provided insight as to how the students were attempting to solve the analogy problems as well as specific areas where the students were having difficulty.

The quantitative data allowed an examination of whether the severity of a student's reading disability had an affect on the student's capacity to improve his proficiency with analogy problems. This data also made it possible to determine which students showed the most improvement in their ability to reason by analogy. Several variables were compared using a Pearson r coefficient, and these correlations were reported. The information for the first question was organized under general topics, with each topic having a short explanatory paragraph as well as specific examples.

The quantitative data from questions two through five were then reported and displayed on scatter diagrams. These research questions were:

2. Is there a relationship between a reading disabled student's receptive vocabulary and his ability to solve analogy problems?
3. Is there a relationship between a reading disabled student's age and his ability to solve analogy problems?
4. Is there a relationship between a reading disabled student's general intelligence and his ability to solve analogy problems?
5. Is there a relationship between the severity of a student's reading disability and his ability to solve analogy problems?

Each section contains information which is relevant to the question under consideration. Its purpose is to provide a setting in which the findings will be more easily understood. The results of the Pearson r coefficients, which formed the basis for the conclusions for these four research questions, were reported. The student justifications which were included in this section are reported in the student's words. It was decided that verbatim accounts of the justifications would provide information which would be more meaningful than accounts which were edited.

FINDINGS FOR QUESTION ONE

Information from the Audio Tapes

A THEORY OF ANALOGICAL REASONING In the present study, it was possible to determine which steps the students were using to solve the verbal analogy problems by listening to the audio tapes. In determining these steps, the analogies were separated into three categories: those where the students spontaneously used the mapping step, those where the students did not use the mapping step, and those where the instructor guided the students to the correct answer.

All of the initial instruction, as well as the teacher and student modeling, contained the mapping step. Even during the instruction, when the teacher was guiding the students to the correct answer, the mapping step was often included. However, once the students started answering the analogies independently, no attempt was made to force the students to use the mapping step. As long as the students were able to discover the correct answer and justify their choices they were allowed to continue. The students almost unanimously chose to omit the mapping step from the analogy solutions. In the present study, 1049 separate analogy justifications were transcribed. Table 2 illustrates the number of analogies in each category.

TABLE 2

The use of the mapping step in student solutions.

CATEGORY	NUMBER
Mapping step not used	866
Mapping step used	2
Instructor guided solutions	181
Total	1049

From this information, a theory of analogical reasoning was proposed. This present theory is similar to the theory proposed by Grudin (1980), but is intended to apply to a different population. A description of the present theory and a flow chart to explain the steps in the theory are included in Chapter V.

INSTRUCTOR LED SOLUTIONS The following discussions are examples of instructor led solutions. When it was necessary to interrupt the independent explanation of the students, it was usually in an effort to guide the student toward the correct answer without simply providing the student with the answer.

T. Pencil is to write as piano is to...

St. Key.

T. How are pencil and write related?

St. Because you write with a pencil.

T. Right. You write with a pencil. Can you think of any way that pencil and piano are related?

St. Because you play with this one and you write with this one.

T. OK. We have pencil is to write as piano is to...

St. Play.

T. Why would you say play?

St. Because you play a piano.

T. OK, J.

St. Birds, feathers.

T. How are feathers related to bird?

St. 'Cause they have feathers.

T. Where are the feathers?

St. On its wings.

T. Aren't they all over the bird?

St. Um hum.

T. Go on now. How about fish?

St. Goes in the water.

T. What do you match with fish?

St. Gills.

T. Why?

St. Because they breathe out of them.

T. Are gills all over a fish?

St. No...scales.

T. Why do you choose scales?

St. Because they're all over.

T. J.

St. City is to pretty as coat is to town.

T. How are city and pretty related?

St. I don't know.

T. Think.

St. A city is pretty.

T. No. How are city and pretty related?

St. Beats me.

T. Forget the meaning. It's got nothing to do with meaning.

St. They are rhyming. And coat and boat.

T. That's right, they rhyme.

In an effort to make the analogies easier for the students to complete, the students were often instructed to change the analogy into a quasi-analogy as soon as they were able to figure out the relationship between the A and B terms.

This was an attempt to lead the students right into the correct answer by providing a context for the solution. This proved to be the case in almost every analogy where the student had correctly figured out the relationship between the A and B terms. Of course, the value of this instructional method lies in the ability of the student to match the first two terms correctly.

T. OK, A.

St. Air...

T. Breathe.

St. Air, breathe, water.

T. This is drink, cup, oxygen, glass. What does breathe have to do with air?

St. You breathe in air.

T. OK. You breathe in air, so what has to do with water?

St. Would it be the third one?

T. Oxygen?

St. No.

T. You told me these two are related because you breathe air. And, you blank water.

St. Drink.

T. Good.

T. OK, B. Try the next one.
St. Chop is to axe as paint is to...
T. Tree, brush, summer, artist.
St. Artist.
T. What is the relationship here?
St. An axe chops.
T. OK. You chop with an axe.
St. And you paint with a brush.
T. That's good.

T. OK, D.
St. A bird is to fly as a...
T. Lizard is to crawl, duck, dance, water. How
does bird relate to fly?
St. Because a bird flies.
T. OK. And, a lizard crawl, duck, dance, water.
St. Crawl.
T. A lizard crawls. Right.

After a number of instructional sessions, the students automatically began to turn the proportional analogies into quasi-analogies without any prompting. Their explanations became briefer as they became familiar with this procedure.

T. Go, N.

St. 12 is to 6 as 10 is to 5.

T. Why?

St. 'Cause 6 goes into 12 twice and 5 goes into 10 twice.

T. OK.

T. J.

St. Dear is to read as tear is to rate.

T. Why?

St. Same letters.

T. Very good.

T. K.

St. Seven, eight because eight comes right after seven, and three, four because four comes right after three.

STUDENT MISTAKES There were several reasons why the students gave incorrect answers to the analogy problems. One which stopped the reasoning process before it started was when the student did not possess the information necessary to match the A and B terms of the analogy. It is obvious from this

initial example, that when the student was given the necessary information, he was able to complete the problem successfully.

St. Fruit, orchard.

T. How does fruit relate to orchard?

St. I don't know what an orchard is.

S2. I know what an orchard is.

T. What is it?

S2. It is a place to grow trees.

T. What is on the trees?

S2. Apples and stuff.

T. Fruit. OK. You find fruit in an orchard, right?

St. Fish is to sea. The orchard is a big large area of things and ocean is big like that.

T. OK. You have a lot of fish in the sea and a lot of fruit in an orchard.

T. Do you want to do the bottom one? Siamese...

St. Cat.

T. Collie.

St. Collie.

T. How does Siamese relate to cat?

St. 'Cause a cat might be born and the cat might be born and the people are Siamese.

T. How do you think Siamese relates to cat, S2?

S2. Siamese is a kind of cat.

T. A kind of cat, St. Do you know what a collie is?

St. It's a dog.

T. That's right. It's a kind of dog

The same problem can occur when the student does not possess the necessary information to complete the C and D terms of the analogy.

St. Finger is to hand as strand...

T. OK. Tell us how the first two are related.

St. You have fingers.

T. A hand has fingers. OK. Do you know what this word means?

St. No.

T. Strand. Do you know what the answer is?

S2. Hair.

T. Why?

S2. Because your hair is in strands and your fingers are like strands and they hang down.

T. L, go for it.

St. Red is to apple 'cause red is the color of an apple-
green is to cucumber.

T. Why?

St. 'cause green is the color of the cucumbers.

T. OK.

S2. Wait a minute. A cucumber is not a fruit like the
apple is.

T. Yes, but are they talking about being a fruit?

S2. No.

T. They are just talking about what?

S2. The color.

Both of the previous examples also show us how a student can
infer a relationship between the terms which is not intended
in the analogy (fingers hanging down, cucumber not a fruit).

T. J, do the next one.

St. Beak, turkey, snout...uh, I don't know.

T. I only know of one.

St. Oh, turtle, turtle.

T. I don't think turtles have a snout. Can anyone
think of what has a snout?

S2. A pig.

St. A pig?

T. Pigs and hogs. The round part on a pig's face is a snout.

In the following example, the student discovers the correct relationship between the A and B terms of the analogy but does not make the correct match between the C and D terms of the analogy.

T. Come on, N.

St. Bird is to feathers as fish is to gills.

T. Explain how bird relates to feathers.

St. Well, feathers are all over a bird.

T. OK.

St. And, gills are...

T. All over a fish?

St. You couldn't say they were all over a fish.

T. Well then, I think you better re-evaluate your answer.

St. OK.

T. Fins, claws, gills, scales.

St. Scales.

T. Why did you say scales?

St. 'Cause they are all over a fish.

Distractor items in the answer choices caused many students to select the wrong answer. A word closely associated with one of the words in the problem was included in almost every set of answer choices. Many students made the mistake of choosing this distractor item. In fact, this was the most frequent mistake made by the students in this study. An interesting fact is that many of the students realized their errors while giving their justifications and corrected the errors without any prompting from the instructor.

T. Do the next one, C.

St. Author is to story as artist is to brush.

T. Explain.

St. Picture, it's picture.

T. Good for you. Go ahead and explain it.

St. Well, an author writes a book and an artist paints pictures.

T. Very good.

T. Go, N.

St. Water is to air as boat is to sea...plane, plane.

T. That's better. Explain it.

St. Water is to air because they're opposites-in a sense. You breathe the air and you drink water.

T. And water goes with?

St. Boat, and air goes with the airplane.

T. OK, W.

St. Collar is to neck as belt is to buckle.

S2. Uh uh.

St. No, wait. Waist.

T. Explain.

St. A collar goes around your neck and a belt goes around your waist.

T. OK.

THE JUSTIFICATIONS Several of the younger students had trouble with their justifications. It seemed as if they were unable to focus on the terms and on the relationship long enough to find the same relationship in the C and D terms. It sometimes seemed as if the justification itself caused the students to become confused and lose their train of thought.

T. OK, M. Try one. Bark, puppy, purr--kitten, dog, cat, play.

St. I think kitten and cat.

T. You can only pick one. How about puppy and bark?

St. OK. OK. So I'd say cat because that's a puppy and that's a dog and the dog is the master and the cat is the master and the kitten is the little one and the puppy is the one they master.

T. If the puppy is the little one and it goes with bark, which one of the other ones is going to go with purr?

St. That one.

T. Kitten. That's right. Good.

St. Puppies bark and kittens purr.

T. OK, L.

St. Refrigerator is to meat as bank is to...

T. Cashier, money, spoil, guard.

St. Money.

T. Explain.

St. No, it would be cashier because a refrigerator holds meat and a cashier-a bank has a cashier, 'cause it has, it has the money in it.

T. Well, which one is it?

St. Money.

T. OK.

St. 'Cause a bank is like a refrigerator holding, you

know, stuff in it.

T. Holding money. That's right.

T. OK, M.

St. City is to pretty as...

T. How are pretty and city related?

St. Oh, they are rhyming words.

T. Very good.

St. As coat is to...wear.

T. Wear, pound, boat, knife.

St. Wear, 'cause you wear a coat.

T. How are these related, M.?

St. 'Cause a city is pretty.

T. You didn't tell me that at first.

St. OK. Rhyming.

T. OK. What are you going to do with coat here?

St. Wear.

T. It has to be the same relationship as these.

St. Coat is boat.

T. That's better.

St. I forgot they was rhyming words.

T. You have to keep the relationship the same.

The personality of the students could be seen in their justifications from the words and phrases they chose. It was obvious when the student had a good sense of humor and was trying to be funny. Other students were funny without meaning to be.

T. OK, J.

St. Person, skin, nut, shell.

T. Explain.

St. A person has skin and a nut has-a person has skin all around and a nut has a shell all around it.

T. Good.

T. Try one more, D.

St. OK. Dish, well a dish will always break. I throw my dish across the floor and it breaks and my clothes turn into-my clothes turn into a tear because I go rip.

T. W.

St. Knee is to leg as elbow is to...arm.

T. Why?

St. Because elbow is hooked to an arm and a knee is

hooked to a leg.

T. OK.

T. OK. Fur is to mink. How does fur relate to mink?

St. A mink has fur.

T. You get fur from a mink. What is leather from?

S2. A cow.

St. What?

T. A cow.

St. I'm not gonna wear leather boots no more.

T. Go, L.

St. Potato is to plate as juice is to glass.

T. Why?

St. A potato is like a vegetable. Juice is like a fruit. And then plate goes with the potato and juice you can't really pour it on a plate so it has to go in a glass.

T. OK.

T. Go, J.

St. Clock and hour, when you look on the clock it goes by hour after hour after hour. What's that?

T. Calendar.

St. And a calendar tells the days and they go day after day after day.

T. Do the second one, J.

St. Bucket of water 'cause you hold water in a bucket, and a wallet, you hold your green in your wallet.

T. What would you put down if you were writing it?

St. I would put down money.

T. Money. OK.

ANALOGY AS A DIAGNOSTIC TOOL The previous examples provide one way which analogies can be used as a diagnostic tool. They can be a means of evaluating a student's ability to communicate verbally. Analogy can also be used as a method of discovering how much background information a student has about a specific concept. Once the student knows what kind of relationships to look for, analogy can be used as a means of reinforcing a student's mathematical skills. Analogy can be used to add to a student's background knowledge by entering into a discussion about a specific topic with a group of students or even with just one student. Analogy can be used to see if a student understands a concept or an abstract term by asking the student to provide a concrete analogy which is

related to the initial concept. By examining the following analogies, it will be apparent how this type of information can be found by analyzing the justifications that the students provide.

T. OK, D.

St. Swim is to fish as hop is to grasshopper.

T. I never thought of that one. That is good. What is another animal that hops?

St. Frog.

S2. Kangaroo.

S3. A rabbit.

T. OK, D. Buzz is to bee and growl is to...

St. Buzz is to bee because a bee buzzes.

T. OK.

St. And growl...a tiger growls.

T. OK. A dog growls too, doesn't it? Can anyone think of another animal that growls?

St. Lion.

S2. Bear.

T. OK.

T. OK, T.

St. School is to fish as herd is to...

T. How does school relate to fish?

St. They call fish a school of fish because there are a whole bunch of fish and they call...

T. OK. Fish swim in a school. What has to do with a herd?

St. Animals?

T. It's a kind of animal.

S2. Cow.

T. Cows are in a herd.

S3. Buffalo.

S4. Birds.

T. No, they are in a flock.

S5. Horse.

T. Horses, deer.

T. D, try one. A shoe is to leather as a candle is to blank. How does shoe relate to leather?

St. 'Cause a shoe has leather on the bottom.

T. You're exactly right. How about a candle?

St. A candle...

T. What is a candle made of?

St. Wax.

T. OK. A shoe is made of leather and a candle is made

of wax.

S2. It's also made of honey. I have some honey candles.

T. I've never seen those.

T. OK, A.

St. Strings, violin, because you play the strings on a violin and you play the keys on a piano.

T. Very good.

T. S, how about the next one?

St. Square is to four as triangle is to three.

T. Good. Can you explain that one?

St. A square has four corners and a triangle has got three.

T. Python.

St. Python is a snake and canary...bird.

T. Explain.

St. A python is a kind of snake and a canary is a bird.

T. D. 8 is to 4 as 4 is to...

St. 8 is to 4 because you count to 4 when you are doing

your math. It shows addition. 8, 4 and you add 4 more and it gets up to 8.

T. OK. And what do we do with this 4 here? What goes with 4 that makes the same relationship?

St. 5.

T. Can you think, S2?

S2. 8 is to 4 as 4 is to 8? 8 is to 4 as 4 is to 5?

T. That's what D said. How does 8 relate to 4?

S2. Oh, now I see. 2.

T. OK. Why?

S2. 'Cause 4 plus 4 is 8 and 2 plus 2 is 4

THE ANALOGY PROBLEM An analogy may be a reasoning task for one student and a vocabulary test in an analogy format for another student. The first example demonstrates a student for whom the test was more a measure of his vocabulary knowledge than a test of analogical reasoning. Because the student did not possess the necessary information, no reasoning took place.

T. Go, K.

St. Tactful, diplomatic. I don't know what diplomatic means.

T. It means to be tactful.

St. What does tactful mean?

T. It means to be polite. You are very polite. You watch what you say.

St. And dominate means disarray.

T. No. Dominate means to control.

The second example is also a vocabulary test, but for another reason.

St. Can I do one now? Sale is to sail as blue is to blew. They are homonyms.

T. Very good.

There were several analogies that the students kept missing in one class after another. It didn't seem to matter what age the students were or what reading level they were on. It seemed as if there was some element in that particular analogy which caused the students to miss it repeatedly because they often made the same mistake on these analogies.

T. OK, L, try it.

St. Separate, join.

T. Separate and join. How are they related?

St. Opposites.

T. They are opposites. So what would be the opposite of discover?

St. Find.

T. If you discover something, you find it. That would be the same. So what would be the opposite of discover?

S2. Find.

T. No, the opposite of discover is not find.

S3. Lose.

T. Losing something. Good.

T. Go to the next one.

St. Separate, join, discover, find.

T. How are separate and join related?

St. You join stuff together and you separate them

T. All right. What kind of words are they?

St. Antonyms.

T. They are antonyms. They are opposites. So what about discover?

St. Separate, join, discover. Something you don't discover.

T. What is the opposite of discovering something?

St. Lose.

T. That's right. Lose.

T. OK, B.

St. Separate is to join as discover is to...

T. What are separate and join?

St. Um Opposites.

T. OK. We want the opposite of discover.

St. Uh Found.

T. The opposite.

St. I don't know.

T. You want the opposite. What were you going to say?

St. Can't find.

T. What would happen if you can't find something?

St. Lose.

T. Lose it. You see?

St. Separate, join, discover, find.

T. Look at how these are related.

St. 'Cause when you separate-Oh, they're opposites

T. It's not to discover something. It's the opposite.

What do you think?

St. Separate, join, discover...uh, find?

T. No.

St. Discover, lost.

T. All right. Or lose.

T. K, do the first one.

St. Knife is to food because you eat food with a knife.

T. You cut food with a knife.

St. You cut food with a knife-same thing. And saw is to cut. You cut with a saw.

T. No.

St. You saw down a tree.

S2. No, wood.

St. Wood. Wood's a better answer.

T. OK.

T. Knife is to food as a saw is to blank.

St. Cut.

T. How does knife relate to food?

St. 'Cause you cut up food.

T. OK. That's for a knife. What does saw relate to?

S2. Wood.

St. Wood. Because you saw wood.

T. OK, W.

St. Knuckle is to fist as cornea is to ear or finger.

T. How does knuckle relate to fist?

St. A knuckle is on your fist.

T. Do you know where your cornea is?

St. Your toe.

S2. Your ankle.

S3. Your eye.

St. Oh.

T. Your cornea is a part of your eye.

St. What is that word?

T. Knuckle, fist, and cornea.

St. Your knuckles are on your fist and your cornea-oh-
your cornea is on your toe.

T. No. Your eye. It's a part of your eye.

The following analogy is an example of a situation that was observed repeatedly in the present study. The student who completed this analogy is the student with the lowest reading level in the study and is one of the youngest children. He was able to answer correctly, without any hesitation or discussion, the analogy that many older students before him were unable to answer on their first try.

T. D, why don't you try this one? Knife is to food as a saw is to blank.

St. Wood.

T. OK. Explain it.

St. A knife is to food because you cut your food with a knife.

T. OK. And what's the next one?

St. A saw is to cut wood because you cut wood with a saw.

T. Very good.

Information from the Testing

PERCENT OF IMPROVEMENT It was possible to compute the percent of improvement each student demonstrated in the present study by comparing each student's pretest and posttest scores. The percent of improvement was then compared with the severity of the student's reading disability. It was felt that the more severe the student's reading disability, the less likely the student would be to improve his ability to reason by analogy. This was not shown by the results of the Pearson r , which indicated a correlation of .104. This correlation indicated that there was little, if any, relationship between a student's capacity to improve his ability to reason by analogy and the severity of his reading disability.

It was also felt that the lower the student's mental ability (IQ), the less likely it would be that the student could improve his ability to reason by analogy. The results of the Pearson r correlation, which was $-.251$, indicated that there was little, if any, relationship between a student's capacity to improve his ability to reason by analogy and his mental ability. This, of course, has to be qualified with the statement that the students' stanine scores in the present study were from 2 through 8. If the same correlation were run using students with a lower Stanine score, the results might be entirely different.

As a final means of gaining information from the percent of improvement each student demonstrated on the posttests, the pretest scores were compared with the percentage of improvement on the posttest. Often the students with the lowest pretest scores will demonstrate the greatest improvement on a posttest following instruction with a direct method. In the present study, this was the case. A Pearson correlation coefficient of $-.784$ was obtained when these two variables were compared, indicating a strong negative correlation between a student's score on the analogy pretest and the percent of improvement the student showed on the posttest. This meant that a student scoring low on the pretest would be more likely to show a greater improvement on his posttest score than a student who had a comparatively high score on the pretest.

COMPARING THE PRETEST AND POSTTEST SCORES Information which was relevant to the present study was obtained from a comparison of the pretest and posttest scores on the Woodcock Reading Mastery Test (analogy section). A comparison of these scores provided an illustration of the differences between the two groups of students (on the pretest and on the posttest) as to the average score on the test (mean), the middle score on the test (median), and a measure of the cohesiveness of each group (standard deviation). This information is shown in Table 3.

TABLE 3

A comparison of the students' pretest and posttest scores on the Woodcock Reading Mastery Test (analogy section).

	MEAN	MEDIAN	ST. DEVIATION
Pretest	25.13	26	7.62
Posttest	29.83	30	5.74

A Pearson correlation coefficient was computed using these two groups of scores as the variables. It was theorized that many of the students would show a great deal of improvement since they seemed able to answer most of the analogy problems correctly during the instructional sessions. However, this did not prove to be the case. The Pearson r

value was .856, which indicated that there was a strong relationship between each student's scores on the pre and posttest.

FINDINGS FOR QUESTION TWO

Previous research has indicated that a student's vocabulary level is related to his ability to reason (Harris and Sipay, 1985). A study by White and Alexander (1984) explored the relationship between a student's receptive vocabulary and his ability to solve geometric analogy problems. Results of this study indicated that vocabulary knowledge had a significant effect on the children's performance on an analogical reasoning task.

Contrasting results were found in a study by Nippold and Sullivan (1987). This study did not find a significant relationship between a student's receptive vocabulary and his performance on verbal analogy problems. Nippold and Sullivan theorized that there was no significant relationship between the two variables because the vocabulary words in their study were very simple. This was one means of ensuring that the analogy test would remain a test of analogical reasoning ability and not a vocabulary test.

The results from the present study did not indicate a relationship between a student's performance on the verbal analogy problems and his receptive vocabulary. The Pearson

product moment correlation coefficient yielded a value of .354 when these two variables were compared. Figure 1 illustrates the correlation between these two variables.

FINDINGS FOR QUESTION THREE

Many research studies have demonstrated that the ability to reason by analogy is a skill that improves as a child grows toward maturity. The results in this study indicated that this was, indeed, the case. The age of the students in the present study ranged from seven through twelve. According to Piaget's theory (1950), most children of twelve would be in the formal operations period of development. These children would be expected to have developed (but perhaps, not perfected) the ability to reason by analogy.

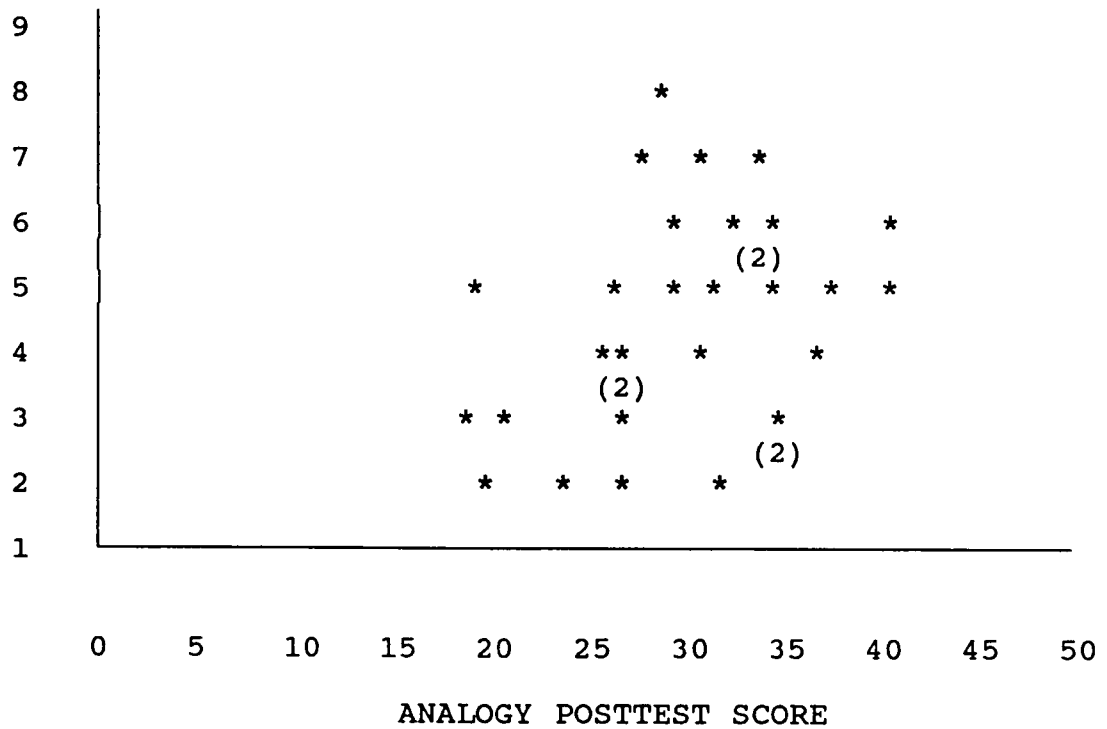
When the students' age and their verbal analogical reasoning scores were compared using the Pearson correlation coefficient, the resulting value was .639. This indicted that there was a strong relationship between a child's age and his ability to reason by analogy. Figure 2 illustrates the correlation between these two variables.

FINDINGS FOR QUESTION FOUR

Previous research has indicated that there is a relationship between intelligence and the ability to reason

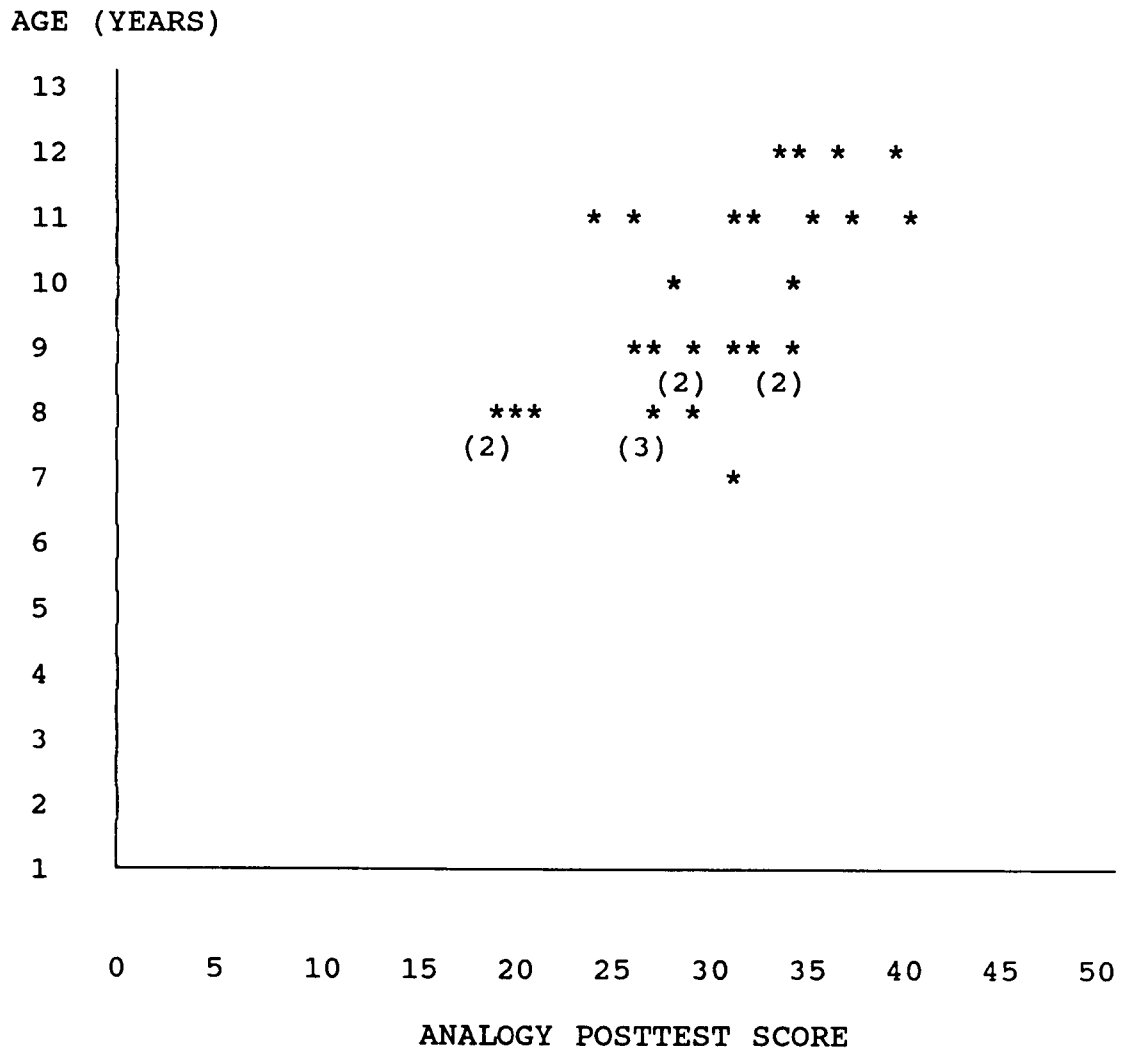
FIGURE 1

STANINE



SCATTER DIAGRAM FOR QUESTION TWO. The correlation between a student's receptive vocabulary and his performance on analogy problems.

FIGURE 2



SCATTER DIAGRAM FOR QUESTION THREE.

The

correlation between a student's age and his ability to solve analogy problems.

by analogy. Since both intelligence and analogical reasoning are cognitive abilities, it would seem that these two processes could have many features in common. However, the results did not indicate this in the present study.

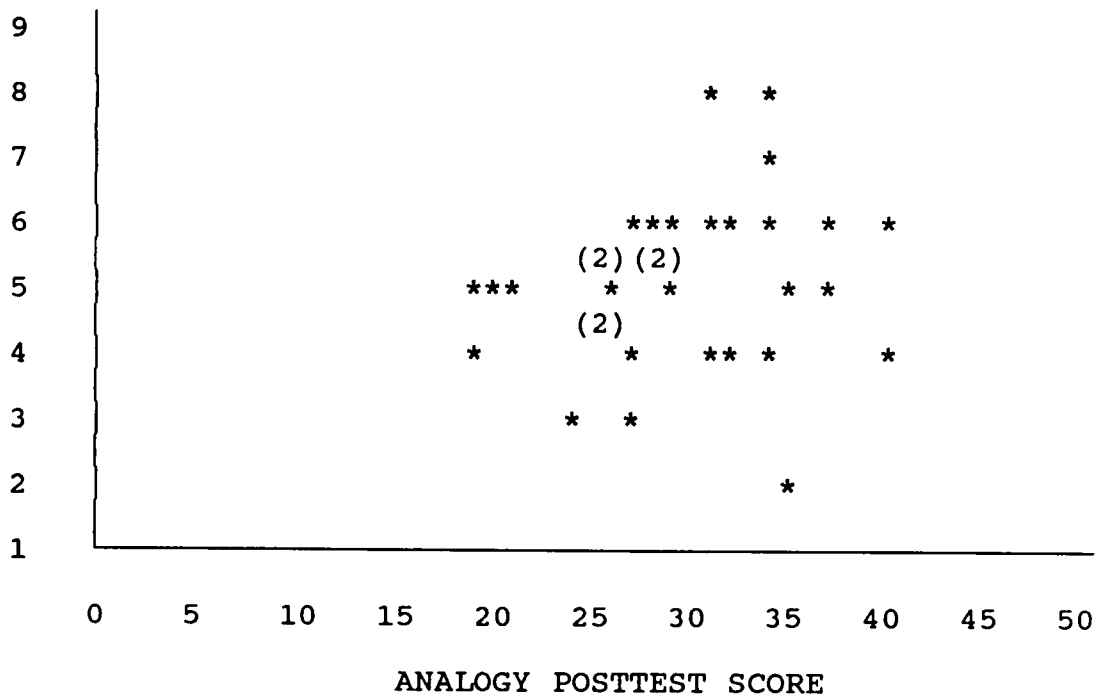
The Pearson r correlation coefficient between these two variables was .166. This indicated that there was little, if any, relationship between a student's mental ability, as measured on the SIT, and his ability to reason by analogy. Figure 3 illustrates the correlation between these two variables.

FINDINGS FOR QUESTION FIVE

Since reading is one cornerstone of learning, it might be expected that the severity of a student's reading disability would have an influence on his ability to reason by analogy. Many cognitive differences which have been observed between good and poor readers may be the result of a student's reading disability. A reading disability may also impact the amount of background knowledge a student is able to accumulate, which could have a negative influence on the student's ability to complete analogy problems.

FIGURE 3

STANINE



SCATTER DIAGRAM FOR QUESTION FOUR. The correlation between a student's general intelligence and his performance on analogy problems.

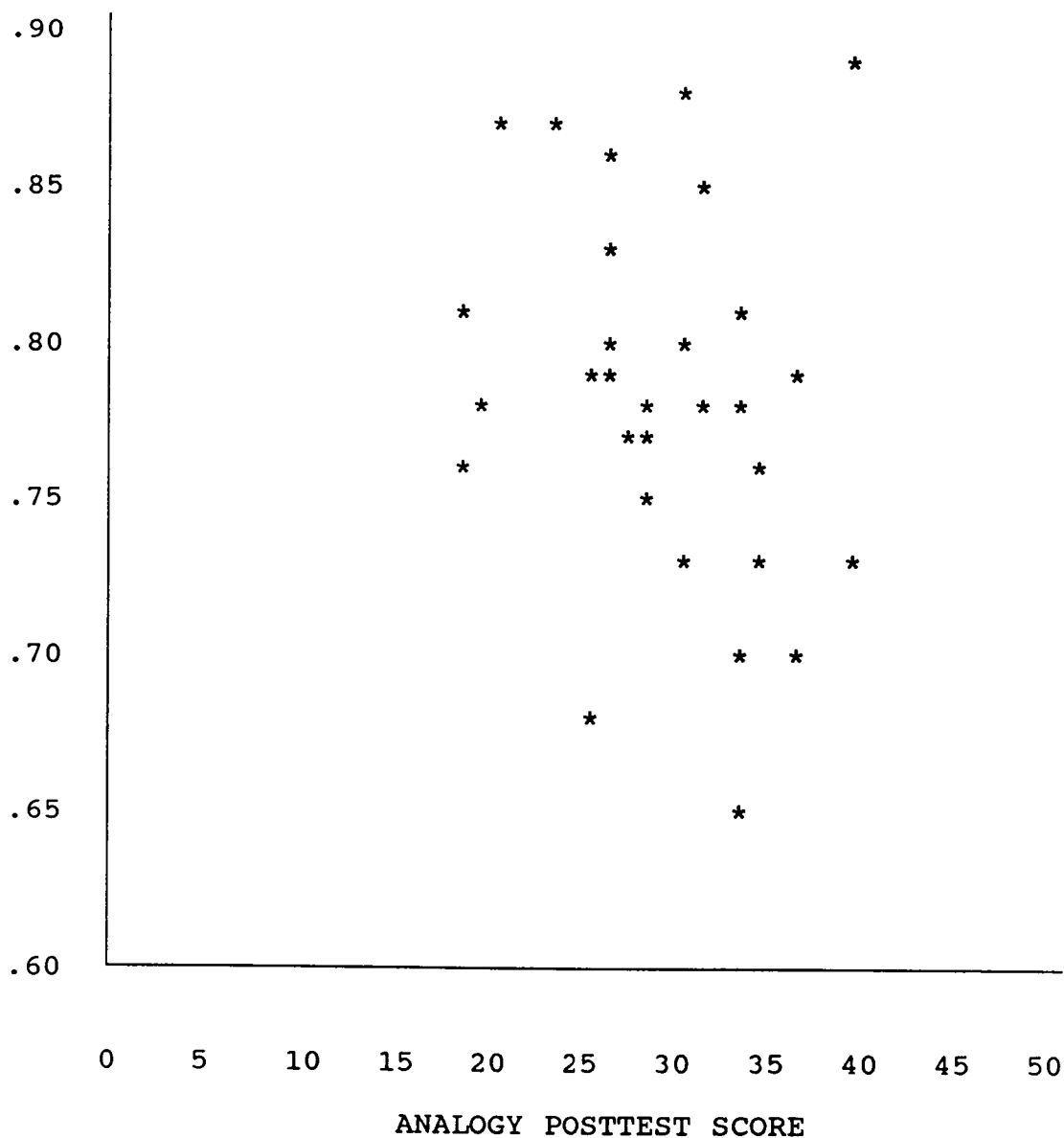
When the Pearson correlation coefficient was computed to compare the severity of a student's reading disability with the student's ability to reason by analogy, the r value was .226. This correlation indicated that there was little, if any, relationship between the severity of a student's reading disability and his ability to complete verbal analogy problems. Figure 4 illustrates the correlation between these two variables.

SUMMARY

This chapter included the information which was collected from the audio tapes as well as the data from the test scores. The researcher attempted to view the information from different perspectives in order to obtain a more complete picture concerning the analogical reasoning ability of these reading disabled students. The data from the testing sessions were evaluated with the idea of obtaining more than just a test score from the results. The overall meaning of a score can depend, in part, on the perspective of the person viewing the results. The researcher attempted to remain objective while at the same time viewing the results from the context in which they were obtained.

FIGURE 4

Severity of
Reading
Disability



SCATTER DIAGRAM FOR QUESTION FIVE The correlation between the severity of a student's reading disability and his performance on analogy problems.

CHAPTER V

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

SUMMARY

Introduction

In the past thirty years, more than one hundred research studies have examined the analogical reasoning process. Very few of these studies were conducted with reading disabled students. The purpose of the present study was to gather information about the analogical reasoning abilities of reading disabled students.

Reading disabled students are at great risk in today's complex society because many have lost one of the most important means of gaining information, which is reading. The written word is a vital medium for communicating information. Many higher level thinking skills, such as inferencing and reasoning, develop in the very classrooms where reading disabled students are at such great risk. Despite this fact, the present study provides evidence that reading disabled students can develop and improve their higher level thinking skills, such as reasoning by analogy.

The results of this study also appear to validate an instructional procedure which can be used to improve the

analogical reasoning abilities of reading disabled students. The higher level thinking skills of these students can be improved despite the fact that they have a reading disability. The key is in providing these students with a concrete procedure they can follow to complete verbal analogy problems. As the students come to understand the process of finding similarities between two concepts which often seem dissimilar, a whole new way of gaining knowledge may become available to them. Learning to transfer information from one situation to another opens a door to "one of the foundation pillars of the intellectual life" (p. 530) (James, 1890).

Research Questions

Data were collected for this study in order to gain information which would be relevant to these five questions:

- A. Are reading disabled students able to develop or improve the ability to reason by analogy?
- B. Is there a relationship between a reading disabled student's receptive vocabulary and his ability to solve analogy problems?
- C. Is there a relationship between a reading disabled student's age and his ability to solve analogy problems?

- D. Is there a relationship between a reading disabled student's general intelligence and his ability to solve analogy problems?
- E. Is there a relationship between the severity of a student's reading disability and his ability to solve analogy problems?

Data Collection

In the present study, data were collected through participant observation, audio taping, and objective testing. These different methods were utilized in order to provide a more complete picture of these reading disabled students: their strengths, their weaknesses, and their capacity to respond to an instructional procedure designed to improve their ability to reason by analogy. Initially, data were collected from 38 students. However, eight of the students were eliminated from the study, either because they did not meet the criteria for attendance at the instructional sessions or the criteria for being considered reading disabled. The data were collected over a four month period from January through May, 1989. The students were all enrolled in The University of Tennessee Reading Center during the spring, 1989 semester. It is believed that the information from the results of this study will prove useful to reading specialists and classroom teachers who are searching for ways to develop

the higher level thinking skills of their reading disabled students.

CONCLUSIONS

A Model of Analogical Reasoning

Based on information from the audio tapes and the observation of the students during the instructional sessions, a model of analogical reasoning was proposed. It was possible to infer from the audio tapes how the students completed the verbal analogy problems. The student justifications made it possible to determine which steps the student used to complete the verbal analogy problems. The students' explanations and the points in the analogies where they hesitated provided the information which was used to propose this model of analogical reasoning. This model is intended to explain how reading disabled elementary school children complete verbal analogy problems.

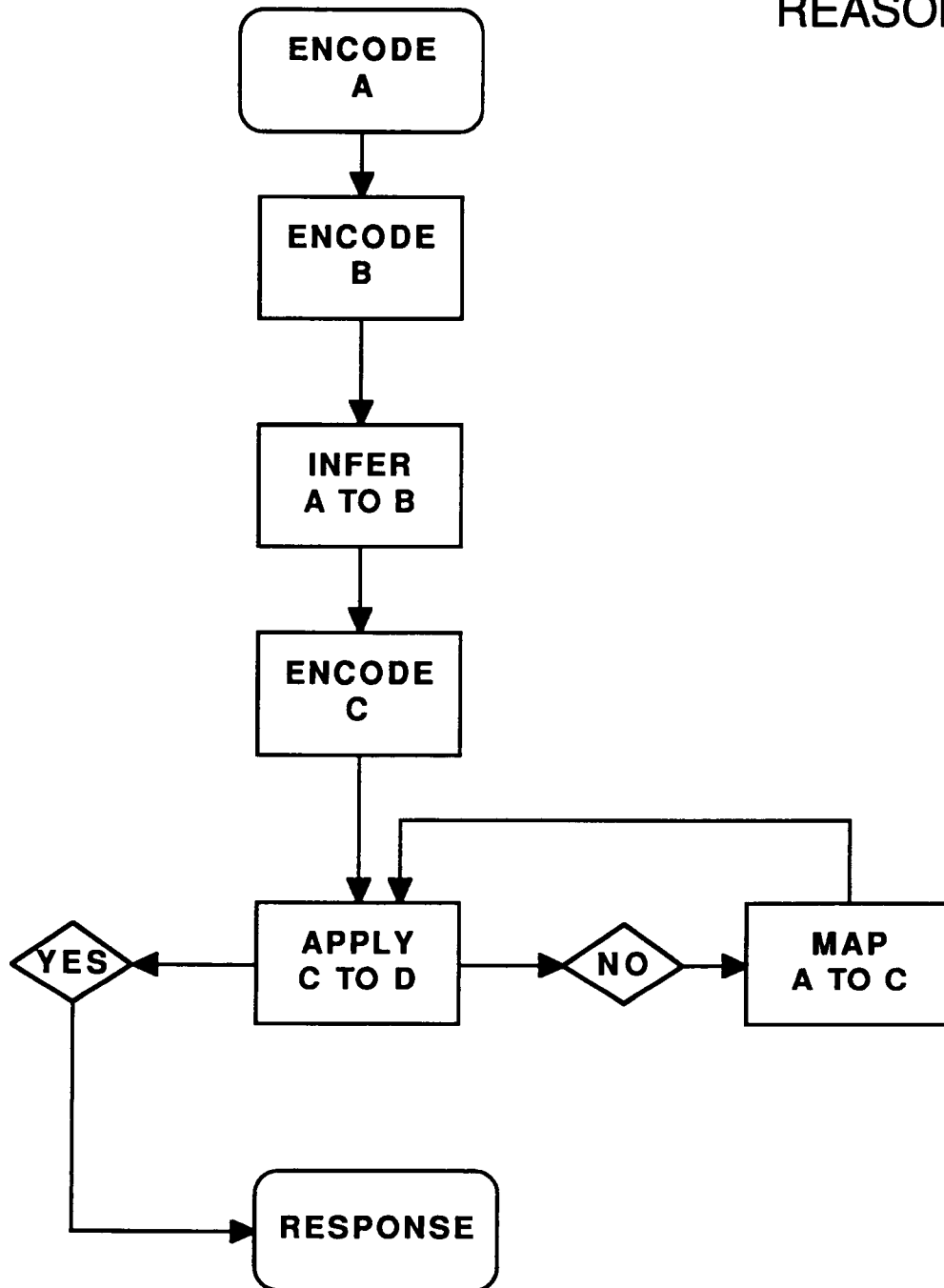
The students seemed to take the greatest amount of time when they were comparing and discussing the relationship between the A and B terms of the verbal analogies. Once the students had figured out this relationship, they quickly matched the C and D terms of the analogies. When the students were asked to compare the A and C terms of the analogy, they seemed to be distracted from their concentration on the

problem. Unless they were unable to make the match between the C and D terms from the information in the base domain, it seemed like an interruption when they were asked to compare the A and C terms. The students usually matched the C and D terms of the analogy before they explained the relationship between the A and C terms, even when they were specifically asked to match the A and C terms. For these reasons, a model of analogical reasoning was proposed in which the mapping step, matching the A and C terms, was an optional step. In this model, the student does not use the mapping step unless he is unable to complete the verbal analogy using the information which was gained from matching the A and B terms. This model is similar to the model proposed by Grudin (1980) but is intended to apply to a different population. Figure 5 illustrates this model.

This theory of analogical reasoning contains encoding steps, an inference step, an optional mapping step, an application step, and a response step. In the present model of analogical reasoning, the first two encoding steps are when the A and B terms of the analogy are perceived and stored in short term memory. In the second process, inference, the relationship between the A and B terms of the analogy is deduced and this information is stored in short term memory. The C term of the analogy is then perceived and stored in short term memory. In the third process, application, the relationship which was inferred between the A and B terms of

FIGURE 5

MODEL OF
ANALOGICAL
REASONING



the analogy is applied to the C and D (D1,D2,...) terms of the analogy. If no appropriate match is found, the student may initiate the mapping step in an effort to gain more information. Based on the relationship between the A and C terms of the analogy, the student returns to the application process in an effort to make an appropriate match. Following this selection, a response is given to identify the correct answer.

If the student cannot find a solution he perceives as being correct, and instead guesses at an answer, this is not considered to be analogical reasoning. Thus, this type of step was not included in the proposed model. Analogical reasoning involves discovering relationships between concepts, and transferring this information between the base and the target domain of the analogy. Any time an answer is given to an analogy problem which is guessing rather than reasoning, this type of solution does not fit in with the proposed model.

An Instructional Procedure

Based on the information obtained from the audio tapes and the participant observation, an instructional procedure for improving students' ability to complete verbal analogy problems was proposed. A 1974 study by Levinson and Carpenter differentiated between quasi-analogies, which are presented in the form of a sentence, and true analogies, which are

presented in the form of a proportion ($A:B::C:D$). The Levinson and Carpenter study demonstrated that the quasi-analogies provided information which helped the students solve the true analogies.

In the present study, the students were instructed to change the A and B terms of the proportional analogy into a quasi-analogy as soon as they discovered the relationship between the A and B terms of the analogy. By using the exact phrase with the C and D terms of the analogy, the students were pointed to the correct answer. They seemed to find it much easier to complete the analogies using this procedure. The students seldom failed to complete the analogy correctly when they used the instructional procedure which was recommended. This instructional procedure is similar to the one used by Loewenthal and Pons (1987) in a study with college students.

This instructional procedure should include explicit explanations of the thinking processes that are to be developed. Modeling these thinking processes in step-by-step sequences was effective in helping the disabled readers improve their ability to reason by analogy. The instructor should model and explain the analogy strategy, but the responsibility for learning rests with the student. Once the step-by-step procedure has been taught, the student must be given opportunities to use the procedure. The practice should be guided by the instructor until the student has mastered the

procedure. Then, the student must choose to use the procedure on his own. In the present study, the students seemed to be challenged by the analogies and anxious to attempt to figure out the answers.

However, in working with students, educators must keep in mind that neither normal nor dyslexic readers form a homogeneous group. Strategic and cognitive differences exist among readers in both groups. Experiments by Bayliss and Livesey (1985) compared the cognitive styles of dyslexic and normal readers. They concluded that both normal and reading disabled students exhibit a variety of cognitive strategies and styles. From the very beginning of a child's school years, there are identifiable cognitive processing styles. In order for students to develop the ability to reason by analogy, this skill must be taught in a manner in which the students feel comfortable and are able to respond. The direct instruction method which is recommended is one which has already proven effective in improving the analogical reasoning abilities of reading disabled students.

Improvement of Analogical Reasoning Abilities

CONCLUSIONS FOR QUESTION ONE Reading disabled students were able to develop or improve their ability to reason by analogy. Reading disabled students often exhibit verbally-based deficiencies such as limitations at the lexical level. They

also seem to have fewer items in their lexicons and often have trouble recalling to memory the items which are there. Learning to read has a great influence on the number of words which are stored in an individual's lexicon. Thus, it might be expected that reading disabled students would have trouble completing verbal analogy problems. They might also be expected to have difficulty improving their ability to complete verbal analogy problems. In the present study, neither of these situations occurred. In spite of any learning disabilities which might be either the cause or the result of their reading disabilities, almost all of these students were able to improve this higher level cognitive skill.

The fact that reading disabled students are able to develop a higher level cognitive ability such as analogical reasoning is important for the many educators whose students are reading disabled. Since reasoning plays a major role in analogical reasoning, inferencing, and reading, problems in one area are likely to cause problems in other related areas of cognitive development. All of these cognitive processes are interrelated, and probably very similar when viewed from their underlying structures. A student's background knowledge has a great effect on his ability to develop or improve these cognitive skills. And, a reading disabled student has often lost the principal means of expanding his background

knowledge. This places him at a disadvantage when compared with a normal reader for developing these higher level cognitive processes which are based on the student's reasoning abilities.

However, the results of this study indicated that when reading disabled students receive the appropriate instruction, they were able to improve their analogical reasoning abilities. A comparison was made between the students' scores on the analogy pretest and the percent of improvement on the posttest. The greatest improvement was found on the students' scores who were the lowest on the pretest, not an uncommon finding. The direct instruction procedure enabled these students to catch up with their peers' scores on the posttest. A Pearson r correlation of $-.784$ was obtained when these two variables were compared, which indicated a strong negative relationship between a student's pretest score and the amount of improvement he demonstrated on the posttest.

Mean, median, and standard deviation scores were computed in order to compare the group of scores on the pretest with the group of scores on the posttest. From these computations, a picture emerged in which certain differences between the two groups were noticeable. The mean and median scores both showed an increase of approximately four points from the pretest to the posttest. This is an indication that the students benefitted from the instructional procedure on completing verbal analogies. The standard deviation of the

two groups of scores dropped two points from the pretest to the posttest scores. This indicated that the scores on the posttest were less varied than the pretest scores, and that this group of students was more cohesive as far as their ability to reason by analogy was concerned.

A final comparison was made between the pretest and posttest scores in order to discover whether the same students who scored high on the pretest would earn the highest scores on the posttest. A Pearson r correlation of .856 was obtained when these two variables were compared. This indicated a strong relationship between a student's pretest and posttest scores. A student who scored high on the pretest was likely to score high on the posttest. These results indicated that even though almost all of the students showed an improvement between the pretest and the posttest scores, most of the students were building on an ability to reason by analogy that they possessed before the instructional sessions began. By removing the three percentage of improvement scores that were by far the highest (107, 122, 217), the remaining 27 students showed an average improvement of only 15.84 percent between the pretest and posttest scores. This indicated that these students were building on a foundation of reasoning abilities rather than learning an entirely new skill. In the three cases where the percent of improvement was much higher than the rest of the students, these three students were probably

improving an emerging ability to reason by analogy rather than building on a firm foundation of reasoning abilities.

Student mistakes can provide valuable information to the classroom teacher. In any instructional procedure, it is important to be aware of the steps in the procedure where students may have trouble. When an instructor is aware of areas where there may be a breakdown in the learning process, it is often possible to guide the students through the area with a minimum of disruption. Several potential problem areas in the verbal analogies emerged from the audio tapes and the instructional sessions.

The initial area of confusion was with the process of reasoning by analogy itself. Several of the students did not understand what reasoning by analogy meant, and they required a great deal of repetition in the instructional procedure. After they seemed to understand what was expected of them, the instructor guided them through the entire process several times. Reasoning by analogy is a complex process which, especially at first, may place strenuous demands on the student's short term memory capacity. It was necessary for the students to remember the three concepts, the answer choices, and the four step procedure in order to solve the analogy problems correctly. Until the instructional procedure was so familiar to the students that it became automatic, all these demands could place a severe strain on the processing

abilities of the younger students. Often a younger student seemed unable to keep all the information in his short term memory long enough to complete the analogy. It was sometimes necessary to step in and attempt to alleviate this difficulty by providing an instructional step or reminding the student of a word meaning or a relationship he had forgotten. Even the older students would exhibit this type of problem when the concepts were difficult for them to understand. As the procedure became more automatic, the students became more independent as well as more proficient in solving the verbal analogy problems. It was easy to see improvement, especially with the younger students, in their ability to deal with this problem.

Another problem area was with the student's background knowledge. When the instructor realized that a student did not possess the information needed to complete the analogy, the instructor intervened. There were several different methods of providing the information. The instructor either provided the student with the information, solicited the information from other students, or attempted to guide the student to remember or figure out the necessary information. Whichever method was chosen, the student needed to possess the necessary information about the concepts before any reasoning could occur.

At times, the students would match the terms in the base domain of the analogy correctly and then incorrectly match the

terms in the target domain. In this case, it was necessary to help the student start through the analogy again until the student was able to match the terms in the target domain correctly. The chosen method depended on the reason for the student's inability to match the C and D terms. The student may not have possessed the information needed to make the match. Or perhaps the student was looking at the concepts from a different perspective than was needed to make the match. When the instructor realized the reason for the student's inability to complete the problem, it was possible to guide the student to the correct solution.

Distractor items in the answer choices (usually words closely associated with one of the terms in the base) often caused students to make incorrect matches. Students occasionally generated associative answers rather than answers arrived at through analogical reasoning. When this happened, the students were encouraged to recognize the relationship in the base domain and to apply the same relationship in the target domain. As the students became more proficient at completing the verbal analogy problems, they were less likely to choose these distractor items. This was seen as an indication that the students were moving away from a reliance on matching the concepts by word associations and moving toward the ability to match the concepts by analogical reasoning.

The analogy format can be used as a diagnostic tool. A verbal analogy problem can be used as one measure of a student's verbal ability when the student is required to provide a justification for his answer choice. The student's justification provides information about the extent of his background knowledge and vocabulary ability. They also provide information concerning the student's ability to communicate verbally as well as an excellent forum in which a student can demonstrate his sense of humor. Initially, many of the students were uncomfortable with this new form of communication as well as in their ability to furnish the justifications. As their confidence increased, however, their ability to furnish the justifications improved. When verbal analogies are used in a cooperative and nonthreatening manner, they can be an ideal format for a shy or hesitant student to begin to speak out in front of his classmates and teacher.

It was apparent from the student responses and the additional student comments which topics interested the students and which did not. It was easy to tell from their tone of voice when students were confident and when they were uncertain. The topics the students seemed uncertain about could indicate a lack of knowledge about that topic. This, in turn, could provide a sensitive instructor with a new topic for further study at another time.

A verbal analogy might be used as a means of evaluating a student's short term memory capacity. A student who is

having difficulty remembering the analogy terms when his classmates are easily accomplishing this task may have a deficit in this area. In a similar vein, a student may have difficulty focusing his attention on a complex problem such as a verbal analogy long enough to figure out the correct answer. This may indicate a cognitive development problem concerning the student's ability to focus his attention for any extended period of time.

Informal methods of evaluating a student's cognitive development are vital in today's classrooms where it is so important for each student to be able to reach his full potential. An instructor must be able to differentiate between students who are seriously in need of referral for special help and those who can best be served in the regular classroom. If used properly, an analogy can be one more diagnostic tool which will facilitate these types of decisions.

The analogy format can be used as an instructional tool. The analogy format can be useful as a method of expanding students' background knowledge on almost any school subject. An instructor who is having difficulty explaining a complex concept may use a concrete analogy as a means of explaining the concept in a way which is easy to understand. An instructor may judge whether or not a student understands a concept by asking the student to provide an analogy which

demonstrates his understanding of the initial concept. An analogy on a specific topic can be used as a means of introducing that topic in a new and challenging manner. A concrete analogy embedded in an expository text may enable readers to comprehend the text more effectively.

The analogy format is utilized in the classroom today as a means of vocabulary development, both in terms of decoding unknown words and as a means of expanding the student's vocabulary. Analogy can be used to enhance a student's vocabulary development because it provides a method of distinguishing between subtle differences in word meanings. However, if the analogy format is only being used to increase a student's vocabulary, instructors are not taking advantage of a very effective instructional procedure for today's complex classrooms.

Inferencing is an important higher level cognitive skill that is a vital part of today's interactive models of reading. A student's inability to make inferences may have a profound impact on his ability to construct meaning from a text. Completing verbal analogy problems provides practice in inferencing as the student determines the relationships between the base and target domain of the analogy problem.

Analogy as a type of figurative language plays an important role in a student's ability to move from an understanding of the concrete to a full understanding of the abstract concepts in his world. Once a student develops the

ability to reason abstractly, his world expands dramatically. The verbal analogy can be a beginning step in this process as either concrete or abstract relationships are explained using the analogy format.

Before an analogy can be used as a diagnostic tool or as an instructional tool, the instructor must take a close look at the concepts used in the analogy and at the setting in which the analogy is to be used. The instructor must choose the concepts for the analogy depending on the cognitive level of the students and the instructional purpose of the analogy. There are many different types of analogies, from geometric analogies to functional or verbal analogies. The type of analogy and the choice of concepts for the base and target domains will determine what type of analogy the problem will be for each student. A single analogy can be a reasoning problem for one student and a vocabulary task for another. An analogy which is a reasoning problem for one student may be an information task for another. These examples help explain why it is important to choose the concepts in an analogy carefully.

Analogy and Receptive Vocabulary

CONCLUSIONS FOR QUESTION TWO There was little, if any, relationship between a reading disabled student's ability to reason by analogy and his receptive vocabulary. The results

of previous research has varied in regard to the influence a student's receptive vocabulary has on his ability to reason by analogy. Harris and Sipay (1985) state that a student's vocabulary level is closely related to his reasoning ability. A study by White and Alexander (1984) found a relationship between a student's receptive vocabulary and his performance on geometric analogy problems.

There are many similarities between the PPVT-R, which provides the measure of a student's receptive vocabulary, and a verbal analogy task. Since both of these tests contain words, performance on both of the tests may be reflective of a student's vocabulary level. As White and Alexander (1984) point out, the demands on working memory for both tests seem comparable. Both of these tests involve a comparison of four concepts as well as word meanings. Thus, it is easy to understand why students scoring high on one test might earn a similar score on the other test.

Contrasting results were reported by Nippold and Sullivan in a 1987 study. This study found that a student's receptive vocabulary was not related to his performance on verbal analogy problems. Nippold and Sullivan theorized that since the vocabulary words from the verbal analogies were very simple, the test was a measure of the student's reasoning abilities rather than a measure of the student's vocabulary skills.

The results of the present study indicate that there was little, if any, relationship between the student's receptive vocabulary and his performance on a verbal analogy task. An attempt was made to include many verbal analogies in the present study that could not be solved by word association alone. A student with an extensive vocabulary could not solve the analogies just because he knew the words and their meanings. It was expected that most of the students in the present study would recognize the words in the analogies and would be able to place the words in the correct context. In order to solve the analogy problems, the student would have to discover the relationship between the base and the target domain; in other words, he would have to be able to reason by analogy. Word knowledge alone would not be enough to solve most of the verbal analogy problems. In this context, it is possible to understand why there might not be a relationship between a reading disabled student's receptive vocabulary and his ability to reason by analogy.

Analogy and Age

CONCLUSIONS FOR QUESTION THREE There was a strong relationship between a reading disabled student's age and his ability to reason by analogy. Many research studies have demonstrated that the ability to reason by analogy is a skill that improves at a child reaches maturity (Kulikowich and

Alexander, 1990; Nippold and Sullivan, 1987; Alexander et al., 1986; Gentner and Toupin, 1986; Nippold, 1986; Rummel and Dykstra, 1983; Sternberg and Downing, 1982; Sternberg and Nigro, 1980; Levinson and Carpenter, 1974). The ages of the students in the present study ranged from seven to twelve. The results of this study provided further evidence that there is a strong relationship between a reading disabled student's age and his ability to reason by analogy.

These findings would seem logical, considering the fact that a child's overall cognitive development changes as he matures. A five year old child may be unable to understand a conservation problem which is understood immediately by an adolescent. Younger children's understanding of their world is grounded in concrete examples that they can examine with their senses. As a child reaches cognitive maturity, he is able to move beyond the need for concrete examples for understanding. He begins to view his world on an abstract level through thoughts and ideas. Verbal reasoning is a complex and abstract task which requires the learner to make comparisons between two pairs of abstract concepts. The very nature of this task requires ever increasing cognitive demands of the learner as the concepts in the analogies become more complex.

Another factor in a student's ability to reason by analogy is the development of his short term memory capacity. Verbal analogy solution requires the learner to store and

compare at least four concepts simultaneously. This may be beyond the capacity of a younger student's short term memory. The amount of information that can be processed at a time varies with the requirements of the task and the abilities of the student (Harris and Sipay, 1985). Semantic information related to the four concepts plus the proposed relationship must all be held in short term memory while the concepts are being compared. The short term memory of the younger students would not be developed to the same extent as that of the older students. For this reason, a student's ability to solve verbal analogies would be expected to improve as he matures.

A third factor which would have an impact on a student's ability to complete a complex reasoning task such as a verbal analogy is the student's ability to focus his attention or concentrate on the task. A child's ability to concentrate on a task for longer periods of time is another skill that develops as he moves through his school years. Any educator would know that preparing a lesson for a first grade student would be very different from preparing a lesson for a sixth grade student. Part of the reason for this difference would be the amount of time which the two different aged students could concentrate during the lesson. As a child matures, his capacity to selectively focus his attention for longer periods of time would improve his ability to complete a complex task such as a verbal reasoning problem.

One reason that the analogies were read orally to the students in the present study was related to these last two factors. By reading the analogies aloud to the student whenever the student did not immediately recognize the words, the student could focus all of his attention on retrieving the semantic information from his long term memory rather than on decoding the words. The student's short term memory could be focused on comparing the semantic information about the concepts as well as on attempting to discover the relationships between the concepts. In the same way a student cannot comprehend what he is reading if his attention is focused on decoding words, a student might not be able to figure out the relationship in a verbal analogy task if his attention is focused on decoding the words or on attempting to figure out the meaning of the words. Reading disabled students are especially at risk when the demands of the task require that several concepts must be stored in short term memory or retrieved from long term memory. Studies are almost unanimous in reporting verbal memory deficits in either short term memory or long term memory among dyslexic readers (Snowling, 1987). An attempt was made to provide a setting in which the influence of these two factors would be kept to a minimum in regard to the students' ability to complete the verbal analogy problems.

Many different factors have an effect on a student's ability to complete a complex reasoning task such as a verbal

analogy. The previous paragraphs have discussed several ways a student's cognitive abilities develop and change as he moves through his school years. The Pearson r correlation between these two variables, age and analogical reasoning ability, was .639. This correlation, which indicates that there is a strong relationship between a reading disabled student's age and his ability to complete verbal analogy problems, adds further information to the body of knowledge which exists on this topic.

Analogy and Intelligence

CONCLUSIONS FOR QUESTION FOUR There was little, if any, relationship between a reading disabled student's ability to reason by analogy and his intelligence. Previous researchers in the field of cognitive development have often theorized that there is a close relationship between intelligence, as measured on tests of mental ability, and the ability to reason by analogy (James, 1890; Spearman, 1927; Thurstone, 1938). Sternberg's theory of intelligence (1977) included only the components involved in analogical reasoning, which indicates that he sees a close relationship between these two process. Sternberg refers to reasoning by analogy as "an important part of what we commonly refer to as intelligence" (p. 99).

Holyoak and Thagard (in Vosniadou and Ortony, 1989) refer to a theory of the basic components of human cognition. This

theory consists of three subsystems: a problem-solving system, a memory system, and an inductive system (which generates new knowledge structures to be stored in memory). Holyoak and Thagard refer to analogical problem solving as a skill which reflects the interactions among problem-solving, memory, and induction. This analogical problem-solving skill is considered to be a proving ground for a theory of cognition. Another researcher, Dejong, (Vosniadou and Ortony, 1989) states "analogy truly is central to thought" and "researchers can agree that analogical reasoning is a fundamental component of intelligence" (p. 346).

Based on information from previous studies which examined the analogical reasoning process as it is related to intelligence, the researcher was expecting to find a correlation between the ability to reason by analogy and intelligence. However, the result of the Pearson r correlation, which was .166, indicated that there was little, if any, relationship between a student's intelligence and his ability to reason by analogy. The researcher can only speculate as to the reason for these results, which are in contrast to most of the information on this subject. Since the subjects in the present study do not constitute a random sample, perhaps there is some unique quality among this group of students which was responsible for these results. This group of students was the entire population of students at the Reading Center, and cannot be considered as being

representative of all groups of students at university reading centers. While it could be assumed that this group is representative of reading disabled students who come to university reading centers, it cannot be assumed so for statistical purposes. The main advantage of random sampling is to ensure that research results are not biased because of a factor which is unique to a particular group of students. In the present study, the researcher has no means of determining if this is the reason for these unusual results. The fact that the students were not randomly chosen for the present study is the study's most serious limitation.

Analogy and Severity of Reading Disability

CONCLUSIONS FOR QUESTION FIVE There was little, if any, relationship between a reading disabled student's ability to reason by analogy and the severity of his reading disability.

An interactive definition of reading views reading as the process of constructing meaning from the text. This text is constructed when the reader makes inferences and elaborations by integrating his prior knowledge with the text he is reading. Reasoning plays a major role in analogical reasoning, inferencing, and reading. All of these cognitive processes are interrelated, and probably very similar when viewed from their underlying structures. Since these cognitive processes are all based on reasoning, it would seem

that a problem in one area could cause problems in the other areas. A study by Davey (1989) reported that poor readers did not seem to reason effectively or attempt to use their background knowledge when answering questions.

Thus, the severity of a student's reading disability would seem to have an effect on his ability to develop other cognitive processes, such as the ability to reason by analogy. In the present study, however, the Pearson r correlation coefficient of .226 indicated that there was little, if any, relationship between the severity of a student's reading disability and his performance on a verbal analogy task.

There is an assumption of specificity in the definition of dyslexia. This assumption is that the cognitive deficits found in dyslexic students are basically specific to the reading act. If the cognitive deficits are not specific to the reading task, and spread into other areas of cognitive performance, this would have an effect on a child's intelligence. And, reducing the discrepancy between reading and intelligence would eliminate one of the main criteria for labeling children dyslexic (Stanovich, 1985; Olson et al., 1989).

The Harris and Sipay formula for reading expectancy takes this factor into account when a child is categorized as reading disabled. The Reading Expectancy Formula gives priority to both intelligence and general maturing (background knowledge) in computing the formula. The Reading Quotient

differentiates between students who are of limited potential based on their mental ability and those who are disabled readers.

If the cognitive deficits which are often found in reading disabled students are specific to the reading act, then the severity of a student's reading disability might not impact on the student's ability to complete verbal analogy problems. The only area of impact might be a negative effect on the student's ability to expand his background knowledge. This impact may be general and not an impact which intensifies with the severity of the student's reading disability.

RECOMMENDATIONS

FOR RESEARCH The focus of this study was the ability to reason by analogy. There have been few research studies conducted with disabled readers which examined their ability to develop or improve this higher level cognitive skill. More information is needed about the effect a reading disability has on a student's potential to develop these important higher level cognitive skills. It is especially vital today because there is such an emphasis in the classroom on developing the higher level cognitive abilities of all students.

Previous research results have provided evidence that there is a relationship between a child's age and his ability to reason by analogy. However, there are still unanswered

questions about the relationship between a child's ability to reason by analogy and his receptive vocabulary. This is especially true as it relates to reading disabled students who may be at risk to have problems developing both of these important cognitive processes. When conducting such a study, it is important to examine the concepts in the analogies which are used in order to ensure that the test measures the student's ability to reason by analogy and not his vocabulary level. This factor would have an impact on the validity of the results of the study.

At present, there is no conclusive evidence as to whether training in analogical reasoning can have a positive effect on a child's reading comprehension abilities. A Pearson r correlation was computed to determine whether there was a relationship between a student's ability to reason by analogy and his improvement in reading comprehension over the four month period of the study. The correlation coefficient of .33 indicated that there was little, if any, relationship between the student's ability to complete analogy problems and his improvement in reading comprehension in the present study. A study is needed which specifically examines these two variables to determine whether there is a relationship between training in analogical reasoning and reading comprehension ability. The instruction in analogical reasoning in any such study must be conducted over an extended period of time and should include discussions concerning the relationship between

reading and reasoning by analogy, as Alexander et al. (1983) mentioned in their study.

There are few studies which have focused on a comparison between a student's reasoning abilities on different types of analogies. Early research results indicate that there are correlations between a student's ability to complete different types of analogies, such as verbal analogies, perceptual analogies, or functional analogies. More information is needed before a conclusion can be drawn about whether a student who is able to solve one type of analogy problem could be expected to be able to solve problems which involve a different kind of analogy problem.

Recent research by Vosniadou (1988) has examined the use of analogy as a means of acquiring information from expository text. This is an area where the use of analogy could make a substantial difference in the classroom if it could be shown that it was effective in this situation. Studies conducted with reading disabled students would add another variable to such experiments and provide information in an area where it is greatly needed.

In the past, the role of analogy has been viewed in a very narrow sense in educational terms. Perhaps the role of analogy in education can be expanded considerably, both in terms of its value as an educational tool as well as its possible value as a diagnostic tool. The present study provided several possible settings in which analogy could be

used as both an educational tool and a diagnostic tool. More information is needed concerning these and other possible uses for analogy in the classroom.

RECOMMENDATIONS

FOR INSTRUCTION Based on the results of the present research as well as the literature review, the use of a direct instruction method as an effective instructional procedure for use with reading disabled students is recommended. The instructional procedure should include explicit explanations of the thinking processes that are to be developed as well as teacher modeling of the step-by-step sequences of these processes. Guided student practice and feedback are also essential if this procedure is to be successful.

The instructional model, based on Sternberg's (1977) model of analogical reasoning, is an effective means of improving the analogical reasoning ability of students. However, based on the information from the present study, it is recommended that students be instructed to view the mapping step as an optional step. When the student requires more information than was obtained from the inference step in order to match the C and D terms, then the student would map the A and C terms. Otherwise, the student would use the information obtained from the base domain to match the concepts in the target domain.

The instructor should choose the concepts in the analogies carefully, keeping in mind the purpose for choosing analogies as an instructional or a diagnostic tool. The purpose would provide the instructor with information which would facilitate that choice. The age and ability level of the students are also important considerations in this decision.

There are many different types of analogies and uses for analogies which were mentioned in the present study. Studies which may be referred to for more information are: analogical study guides, Bean et al., 1985; analogical study unit, Bellows, 1980; analogy strategy to spell unfamiliar words, Englert et al., 1985; analogy strategy to decode words, Goswami, 1986; developing readers' knowledge through analogy, Hayes and Tierney, 1982; analogy as an explanatory device, Vosniadou and Schommer, 1988; analogical transfer across problems, Brown et al., 1986; generating analogies in scientific problem solving, Clement, 1988; analogical problem solving, Gick and Holyoak, 1980; analogies as an aid to understanding and memory, Halpern et al., 1990; geometric analogy task, Kulikowich and Alexander, 1990; people piece analogies, McConaghy and Kirby, 1987; perceptual proportional analogies, Nippold and Sullivan, 1987; functional analogies, Nippold et al., 1988.

When introducing the concept of analogy to students, quasi-analogies are easier for students to understand than

proportional analogies. An effective method would be to use quasi-analogies initially and then gradually change to proportional analogies. The instructional procedure outlined in the present study can then be utilized as the students become more proficient at following the steps needed to complete the analogy task and are able to understand the difference between quasi-analogies and proportional analogies.

When using verbal analogies, the instructor should initially choose analogies where the relationship is easy to understand. In the present study, the easiest relationships to identify seemed to be antonyms, synonyms, or categorization analogies such as: dog:animal, red:color. The studies by Goldman et al. (1982) and by Nippold (1986) provide information concerning the different types of analogies and which types are the easiest for students to understand.

Basal reading series are beginning to include a variety of verbal analogies and basic instructions for their completion. In the past it was difficult to find analogy problems in the basals to use with students. A 1988 study by Bacharach found that three of the four basal series which were examined directly taught analogical reasoning. However, the nature and extent of the instruction varied considerably. None of the series contained Sternberg's model, which has proven successful in helping students improve their ability to complete verbal analogy problems.

Two other sources of analogies have been found which can be used with students. There is a series of books called Recognizing Word Relationships by Richard A. Boning which is available. This series contains verbal analogies on three different levels; primary, intermediate, and advanced. The primary level contains very simple analogies, which are appropriate for first and second grade students. The intermediate level is appropriate for use with upper elementary students, and the advanced level can be used with middle school or high school students.

A new series called Five Minute Workout, from McDougal Littell (1991), contains daily analogies to use with students from grades one through high school. These lessons provide a possible solution for each proportional analogy and indicate the relationship in each analogy. Both verbal analogies and perceptual analogies are included in this material. As the emphasis in the classroom becomes more focused on higher level cognitive abilities rather than on basic skills, more of this type of material will become available to the classroom teacher.

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APPENDIX

ANALOGIES

FORCED CHOICE ANALOGIES

Sing: Songs::Read:	library, music, Books, part
Clap: Applaud::Yell:	thank, whisper, Shout, noise
Boat: Water::Car:	door, ski, truck, Road
Boy: Father::Girl:	cousin, Mother, aunt, son
Shoe: Foot::Glove:	hand, nose, sock, head
Hoof: Horse::Paw:	Cat, bird, fish, tail
Pencil: Write::Piano:	Play, key, work, music
Tree: Forest::Fish:	swim, gills, fins, Ocean
Air: Breathe::Water:	Drink, cup, oxygen, glass
Airplane: Pilot::Ship:	passenger, sail, fly, Captain
Under: Over::Soft:	up, pretty, kitten, Hard
Bread: Food::Robin:	fly, bake, Bird, nest
Child: Children::Man:	girl, brother, boy, Men
Japan: Country::Los Angeles:	ocean, land, City, island
Art: Artist::Science:	paint, Scientist, picture
Poultry: Duck::Fruit:	steak, Banana, bird, vegetable
Skate: Ice::Swim:	suit, float, Water, cold
Garden: Flowers::Field:	Crops, farmer, tractor, plant
Bird: Feathers::Fish:	fins, claws, gills, Scales
Rain: Drop::Snow:	ice, cold, hail, Flake
Pedal: Bicycle::Catch:	tricycle, glove, Baseball, hit
Nose: Smell: Ear:	Hear, hair, cover, skunk

Up:Rise::Down:	Drop,place,high,steps
Milk:Cow::Egg:	shell,cook,Hen,drink
Better:Best::Happier:	sad,Happiest,bet,big
Bird:Fly::Lizard::	Crawl,duck,dance,water
Fish:Ocean::Bird:	Octopus,Sky,robin,starfish
Soft:Fur::Hard:	Rock,blanket,animal,hot
Cat:Kitten:Mother:	father,dog,Baby,animal
Green:Leaf::Yellow:	sky,blue,grass,Sun
Hot:Summer:Cold:	month,Winter,snow,rain
Boats:Sail::Planes:	water,Fly,pilot,cloud
Wing:Birds::Arm:	People,fly,hand,nest
Hairbrush:Hair::Toothbrush:	mouth,comb,teeth,face
Water:Fish::Air:	pond,cloud,Bird,shark
Milk:Glass::Meat:	Plate,drink,eat,ham
Snow:Skiing::Ice:	Skating,running,hop,cold
Nose:Smell::Tongue:	chew,eat,Taste,ear
Road:Car::Track:	boat,bicycle,Train,drive
Cows:Milk::Bees:	sting,drink,hive,Honey
Daughter:Mother::Son:	Father,child,sister,boy
Sister:Family::Carrot:	tomato,Vegetable,eat,salad
Thread:Needle::Nail:	pliers,hit,Hammer,pin
Mane:Lion::Hair:	Person,tiger,bald,curly
Spoon:Soup::Fork:	knife,eat,dinner,Carrots
Floor:Bottom::Roof:	window,Top,door,steps
Sock:Foot::Glove:	warm,shoe,holes,Hand
Red:Color::Robin:	sky,Bird,nest,pink

Green:Go::Red:	jump,walk,Stop,light
Hot:Summer::Cold:	rain,spring,Winter,snow
Bird:Nest::Bear:	Den,house,water,fur
Sky:Blue::Grass:	cloud,Green,cow,red
Eye:See::Ear:	run,speak,Hear,nose
Fin:Fish::Wing:	Bird,snake,seal,feather
Mouse:Little::Elephant:	small,tiny,Big,rat
Bark:Dog::Meow:	Cat,mouse,Puppy,house
Writer:Book::Artist:	paint,Picture,think,brush
Principal:School::Teacher:	books,study,Class,student
Slide:Playground::Desk:	Classroom,chair,pupil,sit
Toe:Foot::Finger:	nail,shoe,glove,Hand
Joy:Sorrow::Laughter:	joke,fun,Tears,sad
Collar:Neck::Belt:	body,buckle,Waist,arm
Skin:Man::Hide:	scales,fur,Animal,fish
Dish:Break::Clothes:	fork,skirt,clean,Tear
Apple:Pie::Potato:	sauce,bake,fry,Salad
Eight:Four::Six:	twelve,two,Three,add
House:Man::Tree:	climb,woods,Bird,build
Blow:Horn::Solve:	answer,Problem,trumpet,loud
Dog:Cat::Sheep:	wool,ram,bark,Wolf
Ship:Dock::Automobile:	compact,car,boat,Garage
Thunder:Noise::Lightning:	Flash,bright,loud,storm
Key:Door::Combination:	turn,forget,Safe,ring
Star:Flag::Ear:	hear,stripe,Head,corn
Slice:Bread::Leaf:	green,Tree,eat,jelly

Dear:Read::Tear:	rip,book,Rate,letter
Knee:Leg::Elbow:	wrist,joint,bend,Arm
Drift:Snow::Dune:	hill,deep,wind,Sand
Fish:Swim::Ant:	hill,water,Crawl,run
Chalk:Blackboard::Ink:	write,color,Paper,draw
Throw:Ball::Pat:	head,Dog,balloon,touch
Sweater:Warmth::Food:	apple,Nourishment,knit,eat
Person:Skin::Nut:	elephant,salty,Shell,man
Elephant:Man:Trunk:	carry,body,suitcase,Hand
Engine:Fuel::Man:	live,woman,gas,Food
Pig:Pork::Steer:	ranch,eat,Beef,steak
Enemy:Hate::Friend:	find,hurt,foe,Love
Girl:Woman::boy:	Man,father,child,student
Forest:Tree::Crowd:	alone,people,branch,Person
Twelve:Six::Ten:	count,Five,two,divide
Water:Ice::Lava:	cold,hot,volcano,Rock
Petal:Flower::Fingers:	Hand leaf pick toes
Rice:Cereal::Apple:	pear,peel,Fruit,flakes
Week:Day::Day:	month,second,Hour,night
Suds:Dirt::Eraser:	soap,clothes,pencil,Lead
Carrot:Plant::Cow:	meat,grow,milk,Animal
Horse:Stable::Baby:	sheep,young,Cradle,cry
Sail:Sale::Blue:	sky,boat,Blew,color
Pencil:Lead::Pen:	blot,write,Ink,erase
Thanksgiving:Nov.:Christmas:	Santa,turkey,Dec.,present
Movies:Watching::Records:	break,play,cartoon,Listening

Shoot:Basketball::Hit:	soccer, score, Baseball, run
Mayor:City::Governor:	county, vote, president, State
Airplane:Parachute::Boat:	rescue, Life Preserver, safe
Egg:Beat::Potato:	yolk, Mash, food, fried
Moon:Evening::Sun:	night, shine, rays, Day
Pit:Peach::Sun:	planet, moon, solar system
Hand:Body::Star:	sun, Universe, eye, twinkle
Wolves:Pack::Cattle:	farmer, cow, field, Herd
Cat:Mouse::Bird:	seed, Worm, eagle, cheese
Net:Fisherman:Gun:	bullet, deer, Hunter, shoot
Father:Brother::Mother:	daughter, Sister, aunt, uncle
Coach:Player::Teacher:	Pupil, school, game, study
Door:House::Gate:	sidewalk, Yard, window, grass
Shark:Fish::Dog:	Animal, puppy, cat, swim
Fly:Spider::Mouse:	rat, Cat, rodent, animal
Loud:Thunder::Large:	monkey, midget, Whale, clap
Crater:Volcano::Chimney:	fire, fuel, , House, smoke
Apple:Banana::Pear:	fruit, grow, beans, Orange
Man:Bread::Horse:	Hay, stable, eat, barn
Finger:Hand::Strand:	Hair, toe, body, blond
Toe:Foot::Head:	arm, ear, Body, nose
Fish:Fins::Bird:	fly, feather, Wings, swim
Mouse:Rodent::Whale:	animal, ocean, Mammal, cat
Nail:Finger::Toe:	shoe, sock, Foot, leg
Water:Air::Boat:	sail, sea, Airplane, car
Climb:Tree::Row:	branch, line, Boat, sail

Refrigerator:Meat::Bank:	cashier,Money,spoil,guard
Peel:Banana::Shell:	sea,fish,sand,Oyster
Finger:Hand::Hair:	Scalp,barber,bald,blond
Day:Night::Sun:	solar,Moon,universe,light
House:Build::Trench:	Dig,bricks,dirt,hole
Page:Book::Leaf:	read,green,trunk,Branch
Tank:Fish::Cage:	zoo,bars,water,Bird
Pat:Tap::Tar:	rut,cur,pit,Rat
Gun:Shoot::Car:	Drive,automobile,fix,load
Fruit:Orchard::Fish:	Sea,pear,swim,tree
Tree:Bark::Body:	voice,Skin,leaves,hands
Meat:Fork::Soup:	bowl,cook,Spoon,napkin
Bed:Sleep::Chair:	table,pillow,eat,Sit
Dreary:Cheerful::Narrow:	light,sad,Wide,day
Bark:Dog::Roar:	Lion,snake,lamb,puppy
Frame:Picture::Cover:	photograph,Book,under,clean
Walks:Man::Swim:	Fish,pool,pier,suit
Warm:Hot::Cool:	winter,summer,Cold,snow
Author:Story::Artist:	book,write,brush,Picture
Oar:Rowboat::Sail:	breeze,row,Sailboat,wind
Dog:Puppy::Cat:	meow,Kitten,scratch,bark
Apple:Fruit::Corn:	pie,Vegetable,ear,eat
Fur:Bear::Feather:	pillow,horse,Bird,coat
Pencil:Write::Hammer:	nail,Pound,saw,pen
Scissors:Cut::Pen:	Write,ruler,cry,ink
Shell:Clam::Cover:	fish,Book,library,ocean

Sun:Day::Moon:	planet,dark,Night,shine
Laugh:Happy::Cry:	Sad,ring,bell,tear
Cold:Ice::Hot:	cube,melt,Fire,freeze
Python:Snake::Canary:	Bird,three,fly,sing
Eye:Face::Finger:	Hand,thumb,ring,ear
Home:Person::Nest:	family,room,tree,Bird
High:Up::Low:	sky,Down,under,ground
Bark:Puppy::Purr:	Kitten,dog,cat,play
Cat:Kitten::Bear:	puppy,dog,meow,Cub
Inch:Foot::Foot:	shoe,meter,Yard,long
Cold:Winter::Hot:	stove,cold,Summer,ice
Cow:Animal::Flower:	Plant,pretty,green,pink
Allison:Girl::Allen:	Boy,brother,sister,friend
Smell:Nose::Touch:	hear,Fingers,hot,taste
Five:Number::Green:	six,blue,Color,count
Days:Weeks::Months:	hours,Years,winter,time
Strings:Violin::Keys:	notes,Piano,music,play
Cause:Effect::Before:	After,once,again,problem
Sleep:Night::Breakfast:	eggs,bright,Morning,eat
Red:Apple::Green:	banana,orange,Cucumber,pick
Chop:Axe::Paint:	tree,Brush,summer,artist
Third:Three::Second:	five,Two,fourth,first
Night:Day::Tall:	person,man,star,Short
Daisy:Flower::Pine:	Tree,rose,branch,grow
Farmer:Plow::Carpenter:	field,job,Hammer,house
Cry:Sad::Laugh:	angry,cold,tears,Happy

Scissors:Cut::Pencil:	paste,tear,school,Write
Under:Over::Soft:	pretty,up,Hard,cotton
Happy:Smile::Sad:	Frown,grin,wink,bad
Library:Books::Aquarium:	table,read,Fish,boat
Apple:Tree::Grape:	grow,purple,pick,Vine
Fence:Gate::Wall:	in,Door,open,walk
Square:Four::Triangle:	Three,number,shape,five
House:Basement::Tree:	Root,branch,under,bird
Oak:Wood::Marble:	table,Stone,house,tree
Antler:Deer::Tusk:	husk,Elephant,tooth,animal
Dog:Kennel::King:	Palace,house,queen,cat
Boy:Man::Calf:	girl,grass,beef,Cow
Lion:Animal::Rose:	smell,thorn,roar,Plant
Axe:Blade::Saw:	sharp,metal,Teeth,cut
Smart:Intelligent::Fortunate:	sad,silly,Lucky,wheel
Turquoise:Blue::Violet:	red,white,Purple,black
Feather:Birds::Fur:	reptile,Mammals,robin,coat
Fur:Bear::Wool:	cloth,coat,Sheep,cotton
City:Pretty:Coat:	wear,town,Boat,nice
Winter:Autumn::Summer:	hot,month,Spring,fall

SELF GENERATING ANALOGIES

Same:Different::Hard:
 Sell:Buy::Wet:
 Remember:Forget::Fast:

Giant:Tiny::Bottom:
Apple:Orange::Bean:
Cook:Look::Bit:
Girl:Sister::Boy:
Skin:Tiger::Bark:
Bird:Sky::Fish:
Chirp:Bird::Howl:
Happy:Smile::Sad:
Library:Books::Aquarium:
Carrot:Plant::Cow:
Scissors:Cut::Pencil:
Under:Over::Soft:
Glass:Smooth::Glue:
Attempt:Try::Create:
Shoe:Leather::Candle:
Mitt:Catcher::Club:
Pitcher:Baseball::Goalie:
Cry:Sad::Laugh:
Scissors:Cut::Pencil:
Under:Over::Hard:
Knee:Leg::Elbow:
Drift:Snow::Dune:
Fish:Swim::Ant:
One:Ten::Ten:
Apple:Tree::Grape:
Dog:Animal::Tree:

Horse:Stable::Baby:
Ghost:Scary::Clown:
Towel:Dry::Cloth:
Needle:Sew::Pencil:
Cherry:Red::Grape:
Cry:Sad::Laugh:
Ahead:Behind::Dull:
Untidy:Messy::Orderly:
Calm:Quiet::Swift:
Clerk:Store::Judge:
Drab:Colorful::Forget:
Land:Car::Space:
Train:Track::Truck:
Nine:Eight::Five:
Snowman:Snow::Sand Castle:
Bird:Claw::Cat:
Knife:Food::Saw:
Clock:Hour::Calendar:
Day:Light::Night:
Seven:Eight::Three:
Dog:Growl::Lion:
Airplane:Pilot::Train:
Same:Different::Rude:
Scale:Weight::Ruler:
Fur:Mink::Leather:
Wolf:Howl::Frog:

Earring:Ear::Ring:
Read:Book::Watch:
Potato:Plate::Juice:
Meow:Cat::Quack:
Bed:Sleep::Chair:
Smooth:Rough::Heavy:
Whistle:Blow::Drum:
Carry:Haul::Ancient:
Separate:Join::Discover:
California:State::Memphis:
Scared:Nervous::Unusual:
Letter:Word::Sentence:
Give:Take::Find:
Egg:Yolk::Apple:
Shoe:Foot::Bonnet:
Huge:Small::Mean:
Ear:Head::Hand:
Under:Over::Spring:
Ask:Answer::Close:
Night:Day::Tall:
Rice:Cereal::Apple:
Triangle:Three::Square:
Author:Story::Artist:
Tree:Forest::Fish:
Air:Breathe::Water:
Shoe:Foot::Glove:

Bread:Food::Robin:
Egg:Chicken::Milk:
Snow:Flake::Rain:
Kind:Caring::Humorous:
Jug:Water::Tank:
Sloppy:Careful::Adult:
Towel:Dry::Key:
Clock:Time::Scale:
Dangerous:Safe::Terrible:
Elephant:Trunk::Bird:
Movie:Theater::Baseball Game:
Day:Hour::Minute:
Food:Cafeteria::Stamp:
Diamond:Brilliant::Jet:
Bucket:Water::Wallet:
Hopeless:Hopeful::Sad:
Shingles:Roof::Lid:
Month:Time::Yard:
Eight:Four::Four:
Follow:Lead::Asleep:
Bird:Nest::Bee:
Sky:Star::Garden:
Book:Read::Ladder:
Seven:Six::Three:
Hot:Cold::On:
Yesterday:Today::Today:

Cry:Laugh::Early:
Water:Drink::Pie:
Tight:Loose::Pretty:
New:Old::Open:
Cage:Bird::Pen:
Heavy:Light::Many:
Two:Four::Five:
Begin:End::Back:
Buzz:Bee::Growl:
Five:Six::Eight:
Kick:Foot::Toss:
Swim:Fish::Hop:
Saw:Carpenter::Paintbrush:
Moo:Cow::Tweet:
Four:Two::Six:
Ocean:Water::Beach:
Over:Up::Under:
Letters:Words::Notes:
Skis:Snow::Flippers:
Water:Liquid::Rock:
Paper:Wood::Tire:
Spin:Twirl::Giggle:
Article:Newspaper::Key:
Uncle:Relative::Tulip:
Truck:Carry::Refrigerator:
Knuckle:Hand::Cornea:

Word:Letter::Sentence:
Chore:Job::Plump:
Mahogany:Wood::Copper:
Ignorant:Educated::Miniature:
Five:Fifteen::Fifteen:
Egg:Fry::Turkey:
Crayon:Draw::Oven:
Beak:Turkey::Snout:
Queen:Ruler::Canoe:
Ruby:Red::Emerald:
Path:Walker::Road:
Arabian:Horse::Poodle:
Raisins:Grapes::Prunes:
Greenland:Island::Asia:
Miserable:Happy::Dead:
Medicine:Doctor::Education:
Cone:Pine::Acorn:
Lumber:Carpenter::Flour:
Chapter:Book::Stanza:
Audio:Radio::Video:
Temperature:Thermometer::Pressure:
Swim:Water::Skate:
Lion:Roar::Dog:
Walks:Man::Swims:
Dog:Log::Hat:
Car:Road::Boat:

Five:Fifteen::Three:
Two:Bicycle::Three:
Beef:Cattle::Pork:
Good:Bad::Beautiful:
Carpet:Floor::Blanket:
School:Fish::Herd:
Gun:Shoot::Knife:
Toys:Toy::Children:
Ancient:Modern::Past:
Rapid:Slow::Last:
Bee:Hive::Fox:
Sandpaper:Rough::Glass:
Hill:Mountain::Pond:
Fawn:Deer::Cub:
Cactus:Desert::Seaweed:
Penny:Dollar::Year:
Feather:Bird::Scale:
Beagle:Dog::Appaloosa:
Sixteen:Four::Thirty-six:
Cat:Cats::Sheep:
Dachshund:Kennel::Canary:
Atlanta:Georgia::Los Angeles:
Foul:Fowl::Dew:
Wide:Narrow::Weak:
Fuel:Engine::Food:
Mackerel:Fish::Sparrow:

Ship:Anchor::Car:
Antelope:Herd::Turkey:
Fine:Good::Raise:
Quiet:Noisy::Permanent:
Bell:Ring::Bee:
Picture:Frame::Water:
Bottle:Liquid::Holster:
Mayor:City::President:
Whale:Mammal::Spider:
Milk:Water::White:
Squeak:Mouse::Caw:
Twenty-five:Five::Four:
Baseball:Bat::Tennis:
Camera:Photography::Yardstick:
Leg:Body::Wheel:
Fall:Bruise::Germs:
Friendly:Vicious::Wrinkled:
Clothing:Coat::Footwear:
Mine:Me::Yours:
Hate:Love::Give:
Cat:Animal::Turnip:
Fish:Guppy::Rodent:
Six:Sixteen::Seven:
Sunrise:Sunset::Day:
School:Teacher::Hospital:
Weak:Strong::Tame:

Soap:Hands::Toothpaste:
Submarine:Down::Rocket:
Thermometer:Temperature::Clock:
Rich:Poor::Brave:
Water:Thirsty::Food:
Whistle:Train::Horn:
Siamese:Cat::Collie:
Pea:Vegetable::Peach:
Apple:Eat::Milk:
Head:Top::Feet:
Lawn:Lawn Mower::Paper:
Calf:Cow::Colt:

Sources for the analogies were:

Macmillan Reading Workbooks

Macmillan Publishing Co.: New York, 1980.

Miller Analogies Test-A test tutor

Arco Publishing Co., Inc.: New York, 1973.

Recognizing Word Relationships

by Richard A. Boning. Dexter and Westbrook
Ltd.: Baldwin, NY, 1981

Scott Foresman and Company Reading Workbooks

Scott, Foresman and Co.: Glenview, Ill, 1981.

INFORMED CONSENT FORM

During the spring semester, 1989, students in the tutoring program at the Reading Center will be involved in a research study. The purpose of this study is to gain insight into the analogical reasoning abilities of children.

All students at the Reading Center will be learning how to solve analogy problems. As analogy problems are found on many intelligence tests and proficiency tests such as the SAT, it is very important that children learn to solve analogy problems correctly. This is also a means of developing higher level thinking and reasoning abilities in children. The students will be exposed to many new words and their meanings during the three months of tutoring sessions, and this will help them improve their reading abilities.

This study will run from February through May, 1989. Your child's participation in the study is voluntary and you may refuse to permit your child to participate. Your child may withdraw from the study at any time during the semester. Forms with your child's test scores will be number coded in order to keep his or her identity confidential. As a participant, your child will be given an intelligence test and a test which measures his receptive vocabulary (the spoken words he understands). Parents will receive a written report of the results of these tests.

If you have any questions about the research, please contact the major researcher, Mary Kay Bordner, Claxton Addition, Room 142, University of Tennessee, 37966, phone 974-5448.

I give permission for my child to participate in the study.

I do not give permission for my child to participate in the study.

Signed

LIMITATIONS

1. Results are based on findings from data gathered from students enrolled at The University of Tennessee Reading Center, spring, 1989, and cannot be generalized to dissimilar populations.
2. Scores may be lower than the student's actual ability since all testing and tutoring were conducted after a regular school day when student attention may have been poor.

VITA

Mary Kay Bordner
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Present Date: May, 1992
Date of Birth: 7-13-42
Place of Birth: Toledo, OH
Marital Status: Married,
3 children, 1 grandchild

EDUCATION

September 1987-
present

University of Tennessee, Knoxville.
Candidate for Ph.D in Curriculum &
Instruction.

September 1981-
May 1985.

California University of
Pennsylvania, California, PA.
Master's Degree in Elementary
Education.

September, 1980-
May 1982.

California University of
Pennsylvania. Certification
in Elementary Education.

January 1975-
May 1980.

California University of
Pennsylvania. Bachelor's
Degree in Early Childhood
Education.

PROFESSIONAL EXPERIENCE

January 1992-
present.

Placement Coordinator, Office of
Field Studies, University of
Tennessee, Knoxville.

September 1989-
December 1991.

Graduate Assistant, University of
Tennessee. Supervisor, field
experience students.

September 1987-
August 1989.

Graduate Assistant, University of
Tennessee. Reading Center
Diagnostician and Diagnostic Report
Writer, Instructor.

April 1985-
May 1987.

Head Instructor, Sylvan Learning
Center.

May 1980-
May 1984.

Substitute teacher and Homebound
Tutor. Chartiers Houston School
District, Houston, PA.

PROFESSIONAL ORGANIZATIONS

International Reading Association
National Education Association
Phi Delta Kappa
Smoky Mountain Reading Council
Southern Association on Young Children
Tennessee Reading Association