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Exploring the Incidence and Predictability Problem of Dyscalculia in a School-Based, Rural Population in a Rural State

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EXPLORING THE INCIDENCE AND PREDICTABILITY PROBLEM OF DYSCALCULIA IN A SCHOOL-BASED, RURAL POPULATION IN A RURAL STATE

An Abstract of a Thesis

Submitted

In Partial Fulfillment

of the Requirements for the Degree

Specialist in Education

Karen Kimberley Annis

University of Northern Iowa

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ABSTRACT

The term learning disability denotes the inability to learn in keeping with one's potential when presented with the usual curriculum. Dyscalculia is learning disability manifested in the area of mathematics curriculum. Limited research exists in the area of dyscalculia in terms of both incidence and identification procedures. However, a fairly large number of school-aged children show deficits in this area. Despite the necessity for knowledge of mathematics, little emphasis is placed on the identification and remediation of mathematical learning disabilities. A prominent neurologist (Rosenberger, 1989) has hypothesized recently that as much as 10% of the population of school-aged children in the United States may be affected by this disorder, more even than are affected by dyslexia (Rubin, 1990). It is important, therefore, that the issue be studied further.

In the study, students with a 1.5 standard deviation difference between their normalized Iowa Tests of Basic Skills (ITBS) (Hieronymus & Hoover, 1986) reading score and their normalized ITBS math score were defined as dyscalculic if the reading score was at least average and the math score was lower than the reading score or as dyslexic if the ITBS math score was at least average and the reading score was lower

than the math score. With these definitions, it was found that dyscalculia did not comprise as much as 10% of the 104 students studied. Implications for laterality as a discriminant between dyslexia and dyscalculia could not be drawn and the generalizability of the clinic based results obtained by Rosenberger (1989) was questioned.

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This Study by: Karen Kimberley Annis

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has been approved as meeting the thesis requirement for the Degree of Specialist in Education

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Many Came, Few Saw . . . (Those who know will understand) . . . Everybody Probably Already Figured This One, I Can Go There Happily, Now That It's Done!!!

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CHAPTER 1

INTRODUCTION

The term learning disability is an inclusive term denoting the inability to learn in keeping with one's potential when presented with the normal curriculum. This term is often designated by a discrepancy of one standard deviation unit between academic achievement and average to above average intellectual functioning on a standard regression table (Iowa Special Education Division, 1981).

Limited research exists on the incidence of dyscalculia in the normal population (Sharma & Loveless, 1986). Formal identification of children with this disability is minimal, making it appear that the incidence of dyscalculia and acalculia in children is small. However, a fairly large number of school children exhibit difficulty in understanding arithmetic concepts and applications, whether or not they have a disability (Byrnes, 1975). Badian (1983) found that 6.4% of the students in a rural United States sample they studied experienced difficulty in math where only 4.9% experienced problems in reading. In a related international study, Kosc (1974) also found that 6.4% of the 375 children he studied exhibited characteristics of dyscalculia. Rubin, in a 1990 newspaper article published in The Des Moines Register, quoted Rosenberger, a neurologist from Massachusets, as saying that as much as 10% of the population may be affected by dyscalculia.

Despite the necessity for knowledge of mathematical operations for success in the 20th century, little emphasis is placed on the identification and remediation of mathematical learning disabilities (Bryan & Bryan, 1975). The cause of the omission is difficult to ascertain. Clearly, greater numbers of children are referred to special education services each year for reading difficulties than for math difficulties. According to Cawley (1985), the two phenomena are not isolated occurrences. Although one does not need to understand arithmetic to read, one often needs to know how to read, to do arithmetic.

Rosenberger (1989) contends that children with specific problems in math can be identified by mixed laterality preference, disorders of visouspatial learning, and attention disorders. He discusses a probable neurological cause of the three dimensions. However, in the methodology section of his article, he operationally defines dyscalculia and dylexia as being based on the child's performance on the Key Math Diagnostic Arithmetic Test (KDMT) (Connolly, Nachtman, & Pritchett, 1971) and the Woodcock Reading Mastery Tests (WRMT) (Woodcock, 1973).

> "Achievement quotients" for performance on these two tests were calculated for each child by comparing the

> total test grade score from the Key Math and the total test grade score from the Woodcock test with the child's actual grade placement (years and tenths) at the time of the test, and multiplying by 100. Those children for whom the reading achievement quotient above 100, and the difference between the two 20 points (approximately 1.5 standard deviation) or greater were designated "dyscalculic." Children who met the converse criteria were designated "dyslectic." (p. 216)

There is nothing in the article to explain the definition shift. Personal correspondance with the author resulted in the receipt of a copy of the 1989 article "Perceptual-motor and attentional correlates of develomental dyscalculia." Consequently, Rosenberger's results from a study of how two groups identified as dyscalculic or dyslexic differ on a wide range of measures were based on a discrepancy definition and not an attribute definition.

Statement of the Problem

The problem for the study had two components: (a) what is the incidence of dyscalculia in a rural area? and (b) do children with dyscalculia differ from children with dyslexia in regards to laterality preference?

Importance of the Study

Whenever a child does not progress in learning the material in a content area, educators become concerned. Several generic questions can arise, i.e., Is there a problem with the curriculum? Are there more effective teaching methods available? Is the child performing to his/her intellectual potential or is there something within the child that is interfering with the learning process? In elementary schools, children are usually not consulted about what they want to learn, especially in mathematics. When a neurologist is quoted in a newspaper article as stating that the incidence of dyscalculia may be as much as 10% in the population, educators can assume many things. They might look to the pedegogy and curriculum used in their schools; they may look to the school psychologist and ask "Why aren't we identifying more students?; or they may look to the child and ask, "What is wrong with you and how do we fix it?"

When a child fails to learn, professionals will seek to find out why. Often educators are willing to accept the notion that the problem lies <u>within</u> the child. When a physician (Rosenberger, 1989) publishes an article providing a potential neurological cause to explain the dysfunction, an explanation which assumes a "within the child" basis for non-learning, educators can assume that they need not look further to the curriculum or pedagogy for possible revision. It is, therefore, important to have theory, rationale, and assessment procedures that clearly distinguish between disorders.

It is important to note whether the reported results can be generalized to the population under question. Benson

(1985) stated that rural populations are significantly different from non-rural populations and require special consideration in the planning and implementation of special services. It is important to ascertain the generalizability of results obtained in a non-rural population to that of a rural population. Incidence rates affect pedagogy. If educators feel that this disability is of high incidence proportions, it is possible that fact will affect the way they teach mathematics as well as the way they identify children with difficulties. It is important that incidence figures such as the one Rubin quotes are verified on the population affected.

Research Questions

The questions examined in this study were: (a) Whether the incidence of children identified as dyscalculic is as much as 10%? and (b) Whether mixed laterality preference differentiates children with dyscalculia from children with dyslexia?

Limitations

1. No comparison was made of those students showing dyscalculia discrepancy and those already designated for special education services for math. The researcher had no way of knowing how many of the children in the sample were

already referred for special education. Generalization of the results is limited to non-referred populations.

2. Those children already served in the resource room were not removed from the sample. The researcher did not know the make up of the cluster sample or the number of students already served. The limitation of generalizability to a non-referred population applies here as well.

3. The rural school districts were not randomly selected from all Iowa schools meeting the criteria. They were selected based on proximity and accessibility. The researcher had concluded a practicum experience in one of the school districts used, the other two were geographically close in relation to the former. While it is not believed that the researcher's presence in the school district caused a change in the composition of the students, their Iowa Tests of Basic Skills (ITBS) (Hieronymus & Hoover, 1986) performance, or the way they performed on the laterality scale (the researcher was not familiar with any of the students who participated in the study), it is possible that the sample, being one of convenience, was biased. The limitiation caused generalizability problems as well.

4. Limited access to students also caused some generalization problems. Only those students who returned completed permission forms (see Appendix A) were allowed to participate. Only 50% of the total fourth and fifth grades at the three schools returned the forms, creating a sample of limited

size and scope. Also, the researcher did not know the composition of the entire student body of the school district sampled. There was no possibility of comparison of those students who returned the forms to those who did not, due to the denial of access by the schools to the ITBS scores of the students without permission forms. While it is not believed that the make up of the school district populations were so different that the 50% return rate does not represent a random sample of the populations, the question of generalizability of results remains. Also, the nature of the parental permission form, and the inclusion of a discription of the dyscalculia as a learning disability in mathematics, could have altered the sample population. It is conceivable, albeit unknown, that parents who felt that their child may be experiencing difficulty in the area might not have wanted their child identified as dyscalculic, and may therefore not have signed the permission form, thus causing the sample to be biased. See Appendix A.

Definition of Terms

1. Learning Disablity--The inclusive term denoting the inability to learn in keeping with one's potential when presented with the instructional approaches of the regular curriculum. The inability to learn efficiently is manifested as a disorder in an individual's ability to receive, organize, or express information relevant to school functioning and is demonstrated as a severe discrepancy between an individual's general intellectual functioning and achievement in one or more of the following basic skills areas: School readiness skills, basic

> reading skills, reading comprehension, mathematical calculation, mathematical reasoning, written expression and listening comprehension. A learning disability is not primarily the result of sensory or physical impairments, mental disabilities, emotional disabilities, cultural difference, environmental disadvantages, or a history of inconsistant educational program. (Iowa Special Education Division, 1981, p. 1)

2. Dyscalculia--For the purposes of this study, dyscalculia was defined as the existance of a discrepancy of 1.5 standard deviation units between a low Math Composite score and a higher Reading subtest score obtained on the ITBS, a standardized group achievement test. The reading score must have fallen above the mean in order to qualify for this definition. The definition is similar to the one used by Rosenberger in his 1989 study. The only difference was in the use of subtests from the ITBS standardized achievement battery in place of the Key Math Diagnostic Arithmetic Test (KMDT) and the Woodcock Reading Mastery Tests (WRMT) to define the achievement levels of each student. Correlation coefficient between the KMDT and the ITBS was reported (Connolly, Nachtman, & Pritchett, 1971) to be .78 and the correlation between the WRMT and the ITBS was also reported to be .78 (Woodcock, 1973).

3. Dyslexia--For the purposes of this study, dyslexia was defined as the existance of a disrepancy of 1.5 standard deviation units between a high Math Composite score and a low Reading subtest score as obtained on the ITBS, the math score

must have fallen above the mean in order to qualify. The defintion is similar to the one used by Rosenberger in his 1989 study. The only difference was in the use of subtests from the ITBS standardized achievement battery in place of the KMDT and the WRMT to define the achievement levels of each student.

4. Lateralization--Specialization of the hemispheres of the cerebral cortex for various cognitive, perceptual and motor or sensory activities (Sattler, 1982). For the purposes of the study, laterality preference was defined by the hand, eye, arm, and leg movements the child used during a structured task. Mixed laterality was defined as any deviation from either all right preference or all left preference.

5. Rural--For the purposes of the study, rural was defined as a school district with a population under 25,000 that is over 20 miles away from a city with a population over 75,000.

CHAPTER 2

LITERATURE REVIEW

In this chapter, the reader will find a discussion of current definitions of dyscalculia, a discussion of current research as related to incidence factors, and a discussion of research concerning dyscalculia. A discussion of rural factors as they relate to special education services will follow, and finally, a comparison of the research and definitions concerning dyslexia with those concerning dyscalculia is presented.

The term learning disability, denoting a discrepancy between academic achievement and intellectual functioning, has been widely studied for years. Disabilities, such as dyslexia and dysgraphia, indicating difficulty in reading and language, have been given the most attention. However, the similar concept of disability in mathematics, referred to as dyscalculia, has been neglected in the literature, even though it is believed to occur at least as frequently as the other disabilities (Rosenberger 1989; Badian, 1983; Kosc 1974). The neglect of dyscalculia in the literature is surprising due to the importance our culture places upon mathematical knowledge and the necessity of it for success in today's society. Cohn (cited in Kosc, 1974), stated that the neglect may be due to the relatively socially acceptable status attributed to difficulty with mathematics. But, failure in mathematics is debilitating

(Lerner, 1988). Mathematical knowledge is often required for educational and career goal attainment (Rubin, 1990). Mathematical difficulty is not at all unusual and can create serious problems in some cases. A more thorough study of this question seems justified.

Definitions of Dyscalculia

Perhaps one reason for the lack of research in the area is the failure of researchers to agree upon a universal definition for the disorder. Dyscalculia has been defined by several authors. Sears (1986), stated that difficulties in mathematics are possible symptoms of underlying deficits in cognitive skills, including auditory memory, visual-motor coordination, and/or perception of spatial relationships. Dyscalculia, according to Sears, is the term used to refer to the difficulty encountered when learning about mathematical concepts and quantitative elements or computations. The difficulty is usually associated with neurological dysfunction or brain damage. Disabilities associated with brain trauma occurring after birth are referred to as acquired dyscalculia. Developmental dyscalculia, on the other hand, is a structural deficit resulting from a genetic or congenital disorder, often accompanied by other disturbances of symbolic function but not associated with any general mental defect. Table 1 lists several characteristics often associated with developmental dyscalculia (Sears, 1986).

Table 1

Characteristics of Dyscalculia

1. Reversed, poorly formed, rotated, or large written symbols.
2. Difficulty shifting processes or thoughts.
3. Interchange of numbers similar in appearance.
4. Difficulty ordering or spacing numbers in arithmetic.
5. Inability to perceive distances between numbers.
6. Difficulty arranging numbers or objects in a series.
7. Difficulty arranging numbers according to magnitude.
8. Failure to read or write the correct value of numbers.
9. Difficulty remembering and following steps.
10. Poor memory for basic number facts.
11. Difficulty seeing objects in groups or sets.
12. Difficulty reading maps and grids.
13. Confusion in mathematical processes.
14. Difficulty with one-to-one correspondence.
15. Failure to recognize or understand operational signs.
16. Difficulty relating auditory with visual symbols or visual with verbal names.
17. Difficulty copying numbers, geometric shapes, designs and so on from models or from memory.
18. Difficulty understanding direction, weight, space, time or measurement.
19. Difficulty moving from concrete to abstract.
20. Difficulty understanding and responding orally or in writing to problems presented orally or visually.

Note. Adapted from Sears (1986)

Despite the similarities, it must be remembered that all children are individuals. Children with disabilities in mathematics will not possess all, or even the same set, of dysfunctions. However, according to Sears, a child with dyscalculia will demonstrate a repeated pattern of one or more of the characteristics listed. Table 2 lists the primary deficits associated with dyscalculia. According to Sears, the listed deficits cause or contribute to the characteristics of the dyscalculic child. Deficits interfere with the normal learning process and make it difficult for the child to acquire the necessary skills for mathematical success (Sears, 1986).

Table 2

Primary Deficit Area

1. Hyperactivity.
2. Distractibility.
3. Perseveration.
4. Lack of motor coordination.
5. Confusion of laterality and directionality.
6. Disturbances in spacial-temporal relationships.
7. Problems in short-term, long-term, or sequential memory.
8. Perceptual disturbances.
9. Difficulties with language, reading, or writing.
10. Difficulties with recognizing a whole when one or more parts are missing.
11. Generalization.

Note. Adapted from Sears (1986).

Redmond (1986) defined developmental dyscalculia as a severe difficulty with numbers and computational skills. A true dyscalculic, according to Redmond, can be referred to as a "hard core mathematical enigma" (p. 585). Children exhibiting dyscalculic-like symptoms may have difficulty handling even basic addition and subtraction and may even be unable to read a standard clock face. Furthermore, they are at a loss as to how to handle temporal and spatial sequences.

Developmental dyscalculia has also been defined as a cognitive disorder of childhood which is manifested as a difficulty in acquiring mathematical skills and comprehension (Slade & Russell, 1971). It has been used as a general term to encompass all aspects of mathematical difficulty (Shalev, Weirtman, & Amir, 1988). More recently scientists such as McCloskey, Caramazza, Basili (cited in Shalev, et al., 1988) studying acquired dyscalculia in adults have devised a model defining normal arithmetic functioning in terms of three subskills: number comprehension; number production; and calculation processing. The number comprehension category includes comprehension of quantities, lexical or symbolic processing, and syntactic or digit order processing. The number production category includes counting, reading, and writing numbers. Calculation is divided into comprehending operational symbols (eg. +, -), carrying out arithmetic activities and memorizing numerical facts.

Luria (cited in Sharma & Loveless, 1986) studied arithmetic disorders without specifically using the term "dyscalculia." He identified four types of disorders: deficits of logic, deficits of planning, perseveration of procedures that are no longer appropriate, and inability to perform simple calculations. The specific deficits are defined as follows:

1. Logical Deficits--difficulties in understanding logical phrases such as "the father's brother." If such phrases are named the child might write the objects in the order named, without regard to the specific relationships involved.

2. Deficits in Planning--the individual fails to apply the preliminary analysis of the problem before he/she solves it. Students will jump into impulsive arithmetic operations and lose connection with the original problem.

3. The inability to perform simple calculations--the child understands the logic of the arithmetic problem, but cannot recall the facts automatically. Generally the facts are recalled by counting.

Luria suggested that different parts of the brain may be activated by different verbal associations, thus, changing a word may change the entire network of connections (cited in Sharma & Loveless, 1986). As a result research associated with Luria has considered mathematical disabilities as manifestations of difficulties in specific areas of the brain (Sharma & Loveless, 1986).

Other research has looked at the cause of the mathematical difficulties, not as a specific brain dysfunction, but rather as a developmental problem (Sharma & Loveless, 1986). Weinstein (cited in Sharma & Loveless, 1986) stated that "developmental dyscalculia results from slower development, rather than impairment, of the cognitive structures underlying arithmetic" (p. 12). A neuropsychological explanation for the disorder links the learning of mathematical concepts to the development of hemisphericity or the specialization of one or the other cerebral hemispheres. It is believed that most numerical activity is specialized in the left hemisphere. It is possible, then, that children with dyscalculia have difficulty with mathematics because they tend to rely on whollistic strategies to solve problems that are best solved analytically. The approach sees the cause of dyscalculia as a function of cognitive style, rather than a deficit, per se. Dyscalculic children, then, may not recognize that analytical processes are more appropriate for the mathematical operations (Sharma & Loveless, 1986).

Kosc (1974) also defined developmental dyscalculia as a problem of development rather than one of defective brain functioning and probably has one of the most inclusive definitions to date. He has done large quantities of work in the area of dyscalculia, and, even though much of his work was conducted in Czechoslovakia, it still has had impact on current work conducted in the United States. Recently an entire issue of the <u>Focus on Learning Problems in Mathematics</u> journal was devoted to discussion and review of his work (Sharma & Loveless, 1986). Kosc defines dyscalculia to be a complicated disorder involving the following:

> Developmental dyscalculia is a structural disorder of mathematical abilities which has its origin in a genetic or congenital disorder of those parts of the brain that are the direct anatomico-physiological substrate of the maturation of the mathematical abilities adequate to age, without a simultaneous disorder of general mental functions. (p. 47)

The definition by Kosc (1974) is elaborated upon in Sharma and Loveless (1986). They state that to define dyscalculia one must take into consideration several factors. One must first consider the relationship between general mental abilities and special mathematical abilities. Kosc (cited in Sharma & Loveless, 1986) claims that one can speak of dyscalculia in adults only when a definite disorder of mathematic ability exists without a simultaneous deficit in general mental funcitoning.

Secondly, one must consider the developmental aspect of the disorder. Developmental dyscalculia should involve only those disorders of mathematical abilities associated with an impairment of the growth or dynamics of the brain, hereditary or congenital, and not with acquired brain damage (Sharma & Loveless, 1986).

Finally, developmental dyscalculia denotes a retardation in the development of mathematical abilities beyond that which would be expected with regard to the child's same age norms. That is, one can only refer to developmental dyscalculia when the child shows a significantly lower level of mathematical age than average, when his/her mental age is normal (Sharma & Loveless, 1986).

Sharma and Loveless (1986) state that the diagnosis of developmental dyscalculia is only applicable to children whose mathematical ages are well below that which would be expected from their estimated average or above intellectual functioning. Children with mathematics disabilities will often demonstrate a difference of 20 or more points between verbal and performance subtest scores on an individually administered intelligence test such as the Weschler Intelligence Scale for Children-Revised (Kosc, 1974).

For Kosc (cited in Sharma & Loveless, 1986), the mathematical age is determined by comparing the performance level of the child on standardized tests of mathematical abilities to the level reached by the majority of that child's same aged peers. A mathematical quotient is calculated using a formula similar to the one previously used for computing the intelligence quotient:

Math Quotient = (Math Age / Chronological Age) X 100

Today, according to Kosc (cited in Sharma & Loveless, 1986), we can compare standard scores from measures of intellectual functioning with those from measures of achievement. A level one or two standard deviations below the mean is considered deficient. Anything lower than 70-75 is considered to be pathological. It follows then, that when diagnosing dyscalculia, one must not only assess mathematical ability, but general intellectual functioning as well.

Kosc (1974) went on to define several different forms of dyscalculia.

1. Verbal dyscalculia is the disturbance of the ability to verbally name the mathematical terms and relations.

2. Practognostic dyscalculia refers to the inability to manipulate mathematically real or pictured objects.

3. Lexical dyscalculia is a disturbance in the ability to read mathematical language.

4. Graphical dyscalculia refers to a disability which is similar to lexical dyscalculia but involves the inability to write mathematical symbols.

5. Ideognostical dyscalculia is difficulty with understanding mathematical ideas and doing mental computation.

6. Operational dyscalculia is a disturbance in the ability to carry out mathematical operations.

Rosenberger (1989) defined dyscalculia as under-achievement in math by normally intelligent school children. Rosenberger believed that specific mathematics underachievement is the result of the failure of dyslectic children with attention deficit disorder (ADD) to autonomize number facts in the early grades. According to Rosenberger, automatization delay often is the precursor of later arithmetic incompetence. Rosenberger contended that children with specific problems in math can be classified by differences in laterality preferences, disorders of visouspatial learning, and attention disorders. He discussed a probable neurological cause of the three dimensions. However, in the methodology section of his article, he operationally defined dyscalculia and dylexia as being based on the child's performance on the Key Math Diagnostic Arithmetic Test (KDMT) (Connolly, Nachtman, & Pritchett, 1971) and the Woodcock Reading Mastery Tests (WRMT) (Woodcock, 1973). He used the existence of a 1.5 standard deviation discrepancy between a mathematics achievement quotient which was below the mean of 100 and a reading achievement quotient which was above the mean of 100 to designate the presence of dyscalculia in a clinic population of fourth and fifth grade children referred to the Learning Disabilities unit of the Massachusets General Hospital. The procedure for which he calculated the achievement quotients is discussed below in the research section.

The lack of consensus regarding the definition of dyscalculia is caused by the difficulty inherent in defining such a concept (Cawley, 1985). The difficulty defining the term makes it difficult to measure and/or label as well. According to Cawley, that which we call "learning disabled" can be defined by a "number of specific attributes, all of which may be measured through univariate or multivariate approaches" (p. 1). Cawley goes on to say that, although the attributes appear to exist in isolation in theory, in practice they do not function independently of one another. The fact that they are not independent makes it difficult to define a specific learning disability such as dyscalculia.

We can, according to Cawley (1985),

> establish a rule which states that an individual can be defined as learning disabled only when there is a discrepancy of at least two standard deviations between level of expectancy and present level of functioning when expectancy is measured by a test of ability and level of functioning is measured by a test of achievement. (p. 5)

Cawley continues on to state that we can limit the definition to include only those individuals "with a minimum of average or near average ability" (p. 5). Also, the rule, according to Cawley, can be established to suggest that the discrepancy might be between two areas of achievement, one of which must show above average performance, instead. Cawley states that rules such as the ones described have established a basis for placement practices.

Incidence Factors

The issue of incidence of the disability has been only minimally touched upon in the research. The formal identification of children with the deficit is problematic, and therefore limited, causing it to appear that the incidence is small. However, a fairly large number of school children show difficulties in understanding math and mathematical concepts at the expected level (Sharma & Loveless, 1986). Rosenberger, in a 1990 interview printed in The Des Moines Register (Rubin, 1990), was quoted as saying that the disability is either as prevelant, or more so, than the reading disorder known as dyslexia, possibly affecting as much as 10% of the population. Similar numbers of incidence have been claimed by Badian (1983) and others (Kosc, 1974; Sears 1986). Badian (1983), found that 6.4% experienced difficulties in mathematics, where only 4.9% had deficits in reading, whether or not they had a disability.

The amount of systematically gathered data concerning the incidence and nature of develomental dyscalculia is small. According to Bryan and Bryan (1975),

> The characteristics enumerated in this section have been based upon clinical observation and rarely demonstrated by a more rigorous method. Indeed, even the data presented by Kosc were such as to suggest that distinct types of dyscalculia were not found. Moreover, the frequency of problems experienced by dyscalculic children, whether in spatial orientation,

> time sense, or what have you, have rarely been compared to those of the non-disabled child. Aside from clinical observations, we are quite in the dark about the nature of dyscalculia. (pp. 240-241)

Research Concerning Dyscalculia

In a recent investigation, Badian (1983), while not specifically investigating dyscalculia, compared the incidence of poor mathematics and poor reading skills among all 1476 students from a rural United States town in grades 1 through 8. Badian used a score at or below the twentieth percentile to define poor achievement in the areas based on achievement scores obtained from the Standford Achievement Test (Madden, Gardner, Rudman, Karlsen, & Merwin, 1973). Findings showed that 32 (2.2%) of the students were low only in reading, 54 (3.6%) were low only in mathematics, and 40 (2.7%) were low in both areas. The total percentage of children that were poor in reading and/or poor in both reading and mathematics was 4.9% and the total percentage poor in mathematics and/or in both reading and mathematics was 6.4%.

Corroborating incidence results were reported in an international research project conducted by Kosc (1974) in Bratislava, Czechoslovakia also on a non-referred population. He attempted to identify cases of mathematical dysfunction from a normal sample population of 11-year old children in regular classrooms. The sample included 199 boys and 176 girls (N = 375) randomly selected from 14 fifth grade classes in 14 schools in Bratislava. Two sets of group tests were given to all subjects as screening devices. Only those students, who scored at or below the 10th percentile of the score distribution on either test were studied further.

Following the screening, the remaining 66 subjects were placed into three groups: those who failed (a) only in the first set of tests, (b) only in the second set of tests, and (c) in both sets of tests. Children with an intelligence score of lower than 90 were eliminated from the study (Kosc, 1974).

A number of tests measuring symbolic functioning were then applied. The tests consisted of (a) the numerical triangle, to assess the student's skills in arithmetic, (b) the Rey-Osterrieth Complex Figure (Osterrieth, 1945), requiring the subject to copy a special design, (c) the test of arithmetical reasoning taken from the Terman-Merrill Intelligence Scale, a shortened version of the Stanford-Binet LM Intelligence Scale, (Terman & Merrill, 1973), (d) the digit memory test taken from the Terman-Merrill, (e) the test of successively subtracting 7 from 100 from Luria's techniques of psychological assessment (Luria, 1966), (f) the numerical square test designed to determine the working curve in an attentional task requiring manipulation of numerical material, and (g) the G-test (Millan, 1969) commonly used in Czechoslovakia, to determine the student's level of reading ability, writing speed, and spelling accuracy. The results of all tests applied were statistically analyzed. Of the original sample of 375 students, dyscalculia was found in a total of 24 (6.4%). This does not mean that each child who showed dyscalculic tendencies differed from the sample in all indicators. However, the structure of the mathematical abilities of the children showing dyscalculic-like tendencies was affected in such a way that they could be differentiated from the group.

Rosenberger (1989) studied 102 children and adolescents from an already identified population, referred to the Learning Disorders Unit of the Massachusetts General Hospital due to difficulties in school. The time factor as related to length of time required to obtain the numbers included in the study, as well as the total number of children from which the sample was gathered, was not reported in the study. Personal correspondance with Rosenberger resulted in the receipt of the 1989 article entitled "Perceptual-motor and attentional correlates of developmental dyscalculia." The article states that the subjects were selected for the study on the basis of their performance on the Key Math Diagnostic Arithmetic Test and the Woodcock Reading Mastery Test. "Achievement quotients" for performance on these two tests were calculated for each subject by comparing the total test grade score from each test with the child's actual grade placement and multiplying by 100. Those subjects for whom the Reading Achievement

Quotient was above 100, the Math Achievement Quotient below 100, and the difference between the two was 1.5 standard deviations or greater, were designated "dyscalculic." Those subjects meeting the converse criteria were designated "dyslexic." A total of 72 subjects met the criteria for designation as "dyscalculic" and 30 subjects fit the "dyslexic" comparison criteria. Subject groups were then compared along seven dimensions including age, sex, Wechler Intelligence Scale for Children-Revised (WISC-R) (Wechsler, 1974) verbal intelligence quotient (IQ), WISC-R performance IQ, WISC-R full scale IQ, Key Math achievement quotient, and Woodcock Reading Mastery achievement quotient. There were more boys in the sample than girls and the mean age of the children designated as having dyscalculia, exactly 12 years, was significantly higher than that of the children designated as having dyslexia, just under 9. Achievement quotients on both tests were signifcantly different between the two groups beyond the .05 level. However, performance on the WISC-R did not differ significantly for the two groups.

Rosenberger (1989) studied several factors to determine which would discriminate between a mathematical learning disability and a reading disability. The factors included perceptual motor correlates, attentional correlates, and measures of laterality preference. Psychometric testing was performed by staff psychometrists of the Learning Disorders

Unit. Tests reported in the study formed part of a battery that normally included 15 to 20 standard tests, and were scattered throughout a session usually lasting from 3 to 3 1/2 hours. The major proportion of the results obtained were nonsignificant and inconclusive. Subjects were compared along five perceptual correlates including the Bender Visuomotor Gestalt Developmental Quotient (Bender, 1938), Beery-Bukenika Visual Motor Integration Developmental Quotient (Beery, 1982), the WISC-R perceptual organizational factor as defined by Kaufman (cited in Sattler, 1986) to include the Picture Completion, Picture Arrangement, Block Design, and Object Assembly subtests of the WISC-R, the Rey-Osterrieth organization score, and the Rey-Osterrieth directionality versus age score. Of these five comparisons only one, the Bender Visoumotor Gesalt Developmental Quotient yielded any significant difference between the two groups. Subjects were also compared along attentional correlates. These included the WISC-R full scale IQ, the WISC-R Freedom from Distractibility Quotient (FDQ) as defined by Kaufman (cited in Sattler, 1986) to include the Arithmetic, Coding, and Digit Span subtests of the WISC-R, Diagnostic and Statistical Manual for Mental Disorders (Third Edition-Revised) (DSM-III-R) (American Psychiatric Association, 1987) factors including hyperactivity, inattention, impulsivity, and peer relations, the Conners Scale (Conners, 1985) and Conners Scale *z* scores. Differences between the dyscalculic and dyslexic groups were significant below the .05 on the WISC-R FDQ and the WISC-R arithmetic subtest when the p value was not corrected for multiple comparisons. The DSM-III-R factor of inattention was significantly different for the two groups at the .002 level.

Laterality Preference

Laterality preference refers to the specialization of the hemispheres of the brain for various cognitive, motor, or sensory activities (Sattler, 1982). Procedures for examining lateralized differences in lower level functioning include motor functioning tests (measuring such factors as finger tapping rate, strength of grip, and motor dexterity), bilateral simultaneous stimulation (touching both sides of the body simultaneously), dichotomous listening, and standard neurological techniques for assessing tactile, visual, and auditory senses (Sattler, 1986). Lateral specialization cannot always be clearly established. However, Orton (cited in Myers & Hammill, 1976), found that children having specific reading disabilities often displayed what he termed as "motor intergrading" or mixed laterality. Newton (1985) described crossed laterality as a situation where the child has established a dominant side of the body for the motor functions, such as throwing or kicking, but has opposite dominance for sensory funcitoning, such as seeing or hearing. The confused patterns of laterality appear to produce a general delay in perceiving the nature of asymmetry believed to be necessary for the acquisition of literacy.

A Laterality Preference Scale was administered as part of the neurological examination performed by Rosenberger during his 1989 study, at the time of the subject's initial assessment at the unit. The test consisted of the tester first punching a hole in the middle of a 5 x 5 1/2 inch piece of blank paper, handing the paper to the child with instruction that it be held lengthwise at the edges with both hands, instructing the child to "look at me through the hole," and noting which eye was used. Next, the paper was crumpled and thrown to the child, with the instruction to "throw it back," and then to "kick it to me with your foot." Hand preference for writing was noted during administration of the written tasks of the examination. Results obtained showed preference for sighting was discrepant from that of motor behaviors more frequently among dyscalculics than among dyslectics (Rosenberger, 1989, p. 217).

Rural Characteristics

That which we call rural is a very ambiguous label reflecting the diversity which exists in needs, resources, economics, politics, and other factors (Benson, 1985). Benson states that the practice of school psychology and the implementation of educational services in a rural setting is different than that of urban settings. Lack of clear criteria for distinguishing between rural and urban has too often caused public policy to be viewed as a generic process which operates under the "one best system" model (Benson, 1985). This, according to Benson, has usually meant the indiscriminant application of urban techniques to rural settings.

However, Hughes and Clark (1981) claim that, despite the across-the-board implementation of urban practices to rural settings, rural schools <u>are</u> distinguishable from urban schools in a number of important ways. Rural schools are less specialized, less well-equipped, and less bureaucratic than are urban schools. Also, they are more oriented towards teaching the "basics," more reliant on the particular aspects and qualities of the individual teachers and staff members, as well as more familial and relaxed in their operating styles than are city schools. The school, whether urban or rural, is part of its community (Butterworth, 1945). It follows then, that the community has tremendous influence on the school and vice versa. Defining the community is essential to planning effective rural school programs (Butterworth, 1945). The services provided by each rural school district will depend, in part, on the attitudes and efforts of the people living within the community (Butterworth, 1945). Special education services which match aspects of the broader community will be optimally effective (Hughes & Clark, 1981).

Nachtigal (cited in Benson, 1985), offers a summary of common characteristics which discriminate between urban and rural settings and which should be considered when planning educational programming for the schools involved. Rural settings are much more homogeneous in their composition than are urban settings. Also, rural schools, according to Nachtigal, are often nonbureaucratic and use oral communication rather than the written memo form often used in urban settings. Rural towns hold traditional values and are much less formal than their urban counterparts. Finally, rural settings often place high value in self-sufficiency where urban settings often leave the matter of problem-solving to the experts (Benson, 1985).

It is necessary to assess the characteristics of the rural school district prior to planning or implementation of special education services (Benson, 1985). Due to the many unique characteristics of the rural setting, it is important to be extremely cautious about the generalization of results obtained from an urban population to a rural one (Hughes & Clark, 1981).

Dyslexia and Dyscalculia, A Comparison

Dyslexia has been defined as the impairment of the ability to read, generally believed to be the result of cerebral dysfunction or damage to the brain (Myers & Hammill, 1976).

According to Cruickshank (cited in Lerner, 1988) people with dyslexia have difficulty recognizing letters and words and interpreting what is seen visually or heard auditorily. The disability is not the result of mental retardation, sensory impairment, emotional problems, or inadequate teaching. Many of these individuals are intelligent in other ways, often having very strong skills in mathematics (Lerner, 1988). Inability to read does not impede aquisition of math concepts (Johnson & Myklebust, 1967). Likewise, children with dyscalculia may excel in reading vocabulary and syllabication skills (Johnson & Myklebust, 1967). The inability to read creates problems in school learning and limits social maturity, social relationships, and the assumption of responsibility (Johnson & Myklebust, 1967).

For many years, dyslexia has been believed to be linked to neurological dysfunction (Lerner, 1988). Recent research by Vellutino, Duane, and others (cited in Lerner, 1988), has shown that some dyslexic individuals have a different anatomical brain structure as well as brain asymmetry that deviated from expected norms. Orton (cited in Myers & Hammill, 1976), working with brain-damaged adults, attempted to explain the occurrence of language disabilities in children without brain damage. Children with no previous brain damage were exhibiting symptoms similar to those exhibited by adults who had sustained cerebral damage. Orton's hypothesis was that children who did not establish hemisphere dominance in particular areas of the brain would display specific developmental language disabilities such as dyslexia.

According to Cawley (1985), reading is one of the most popular areas of evaluation. Cawley states that relationships between reading and mathematics have been studied in a number of ways. He goes on to state that "The general finding is that there is a positive correlation between reading and mathematics and that improvement in reading often results in improvement in mathematics" (pp. 160-161).

Dyscalculia has been associated with a certain type of neurological dysfunction that interferes with quantitative thinking (Myers & Hammill, 1976). Laterality and hemisphere dominance appears to be a predominant theme throughout literature associated with both dyscalculia and dyslexia (Rosenberger, 1989; Myers & Hammill, 1976; Kosc, 1974;). Although mixed laterality preference has been cited by authors in both fields as being different from that which would be expected by same age norms, Rosenberger (1989) reported that mixed laterality appeared more often in those children exhibiting the dyscalculia discrepancy of 1.5 standard deviations than it did in those children exhibiting the dyslexic discrepancy of 1.5 standard deviations. In order to compare the results from one research project to another, there must first be agreement upon the criteria for selecting subjects. The current research was designed to examine the incidence rate of dyscalculia as it occurred in a rural sample as well as the differences between laterality preference among the students meeting the criteria for dyscalculic and those meeting the criteria for dyslexic, based on Rosenberger's discrepancy definition.

Learning disability is a controversial issue that has been debated for many years (Mollen, 1985). Little agreement exists among professionals concerning the definition, etiology, assessment procedures, or remediation processes used regarding learning disabilities. The exact incidence of learning disabilities is unknown due to the difficulties inherent in the definition (Badian, 1984; Harwell, 1989). According to Harwell (1989), estimates range from 2 to over 20% of the population depending on the definition used to identify the disability. Rosenberger, in a 1990 interview printed in The Des Moines Register (Rubin, 1990), was quoted as saying that the percentage of the population affected by dyslexia was around 3 to 5%. During the 1982-1983 school year, 1,745,865, or 3.83% of the total United States school population, were receiving special education and related services (Mollen, 1985).

CHAPTER 3
METHODOLOGY

Subjects

The subjects used in this study were 104 fourth and fifth graders from three rural Iowa school districts in north-central Iowa. School districts were chosen on the basis of the criteria selected for designation as rural for the purposes of this study. However, the schools were not randomly chosen from all of the Iowa school districts meeting the criteria. Schools were chosen on the basis of proximity and accessibility to the researcher, creating a somewhat convenient sample. Students were selected on the basis of returned permission forms. Permission forms were distributed to the entire intact fourth and fifth grade classrooms at the three schools. However, only those students who returned completed permission forms by the requested date were allowed to participate in the study. The return rate was 50% for the study.

Physical Setting

A laterality Preference Scale (discussed later) was administered on the playground in a semi-secluded spot, during normal recess time.

Miscellaneous Equipment

A 3 X 5 piece of white paper with a hole punched through the center was used to administer the Laterality Preference Scale. A pencil was used for the subject to write his/her name on another sheet of paper for the purpose of identifying hand preference for writing.

Procedure

The study was divided into two component parts: (a) recording of the Mathematics Composite scores and the Reading subtest scores of the Iowa Tests of Basic Skills (ITBS) tests, and (b) administration of the Laterality Preference Scale.

In order to enter the school system, as one must do any time a school district is involved, the researcher first contacted by telephone the elementary school principal for each district. After a brief discription of what the study would entail, the researcher asked permission to come to the school and speak to the principal in person to explain the study in more detail. Each school was eager to help and invited the researcher to come any time that was convenient for her. The researcher did so on three separate occasions. It was discussed each time that parental permission forms would have to be signed before test scores could be viewed. This was taken care of by distributing permission forms to each classroom and asking that the children return the forms at the end of the week. The principals in each building requested to be responsible for distributing the forms to the classrooms and gathering the returned ones at the end of the week. The forms were only distributed once to each child.

According to accepted principles, a carefully constructed and comprehensively standardized achievement test battery, based on the curriculum requirements of the classroom, represents the most accurate and dependable measure of pupil achievement available to educators. The most valid achievement test for each individual school is one that defines most adequately the objectives of instruction for that particular school. All of the commonly used principles of validation were applied in the preparation of the ITBS test battery (Hieronymus & Hoover, 1986). Reliability reported for the national sample on Forms G/H for the fourth grade were as follows: Reading subtest scores--.84; Math Composite scores--.87; and for the Complete Composite scores--.97. Reliability reported for the fifth grade, forms G/H were: Reading--.86; Math--.89; and Complete Composite--.97 (Hieronymus & Hoover, 1986). Correlational data between the tests used by Rosenberger in his 1989 study (specifically the Key Math Diagnostic Arithmetic Test--KMDT, and the Woodcock Reading Mastery Tests--WRMT) and the ITBS were reported to be .78 for both tests (Connolly, Nachtman, & Pritchett, 1971; Woodcock, 1973). It was believed that this particular test battery was an accurate predictor of achievement, and therefore was adequate for the designation of dyscalculia or dyslexia as defined by Rosenberger (1989) as a 1.5 standard deviation difference between reading achievement scores and mathematics achievement scores.

For the purpose of the study, the most recent ITBS scores for each school were used. All three schools had administered the ITBS to their fourth and fifth grade classes sometime during 1990; these scores were used. The researcher was concerned only with the mathematics composite scores and the reading subtest scores for each child at this time. National percentile ranks for these subtests were obtained and recorded for each child.

Next the Laterality Preference Scale was administered to the entire sample of students. The procedure followed closely the procedure used by Rosenberger (1989). No validity or reliability information was available for the procedure. Experimenters were two caucasian females, ages 22 and 23. Both were semi-casually dressed and cheerful during administration. No adverse effects were noticed during administration of the scale. The scale was administered during normal recess time.

The procedure consisted of the experimenter first having the child write his/her name on a piece of paper for the dual purpose of identification of the student, as well as identification of hand preference for writing. Next, the experimenter handed the child a 3 x 5 piece of blank white paper with a hole punched through the center and asked the child to "look at me through the hole", noting which eye the child uses. The child was then instructed to crumple the paper and "throw it to me." Finally, the paper was given back to the child with an instruction of "ok, now, kick it to me." For each exercise, eye, arm, and leg preference were noted respectively.

Analysis of Data

The national percentile ranks obtained for each child's ITBS scores were first converted to standard z scores using a unit normal curve table. The discrepancy between the z scores for each child was then computed. Those children with an absolute discrepancy of more than 1.5 z scores between the two recorded ITBS scores, with reading being above the mean were considered dyscalculic for the purpose of this study. Those students exhibiting the converse criteria were considered dyslexic for the purpose of this study, and those students showing no absolute discrepancy greater than 1.49 z scores were considered normal for the purpose of this study.

Laterality preference was scored as either mixed or consistent. Those with either all right or all left dominance were considered consistent in their laterality preference, and those exhibiting any difference at all were considered mixed (eg., right hand, left eye, right arm, right leg, etc.).

Results

Overall Score Analysis

In the present study, the students' percentile ranks for both reading and mathematics were area transformed to normalized standard scores, *z* scores. The mean reading *z* score was found to be .70 with a standard deviation of .76. The mean mathematics *z* score was .74 with a standard deviation of .75. One way Analyses of Variance (ANOVA) for a comparison of the three districts for both reading and mathematics yeilded non-significant differences between districts (Reading $F(1, 101) = 2.86$; Mathematics $F(2, 101) = 2.28$). The discrepancy between normalized *z* scores for mathematics and reading was calculated for each student (see Appendix C), the mean discrepancy for the group was -.02, math was slightly higher than reading, and the discrepancy score standard deviation was .59. The frequency distribution of the discrepancy scores is presented as Figure 1. Pearson Product Moment Correlations between the *z* scores for reading and the *z* scores for mathematics were .72 for total group, .56 withing district A, .76 withing district B, and .72 within district C.

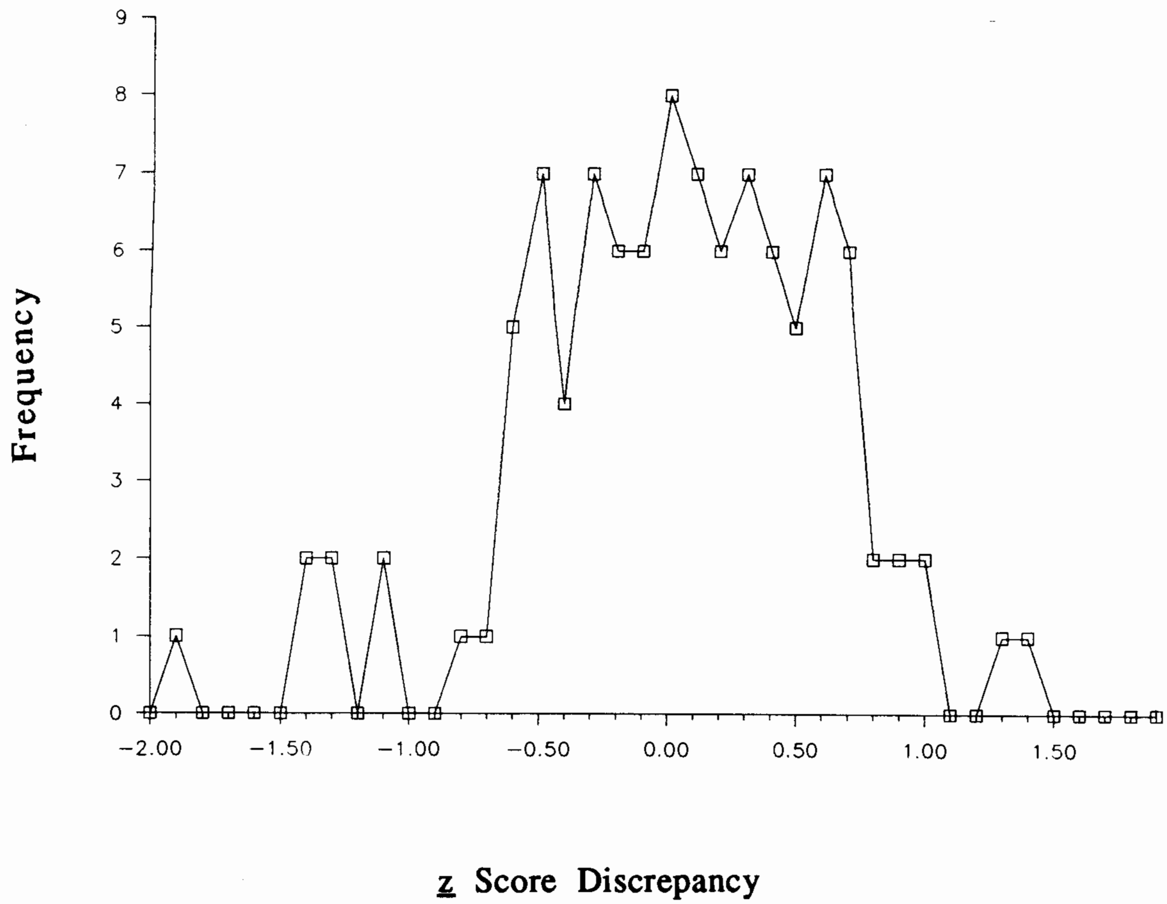

Figure 1. Distribution of Obtained z Score Discrepancies

Note. Reading z score - Math z score = z score Discrepancy

Also, in the present study, 30 students, or 29% of the total sample size exhibited mixed laterality preference. The distribution broke down by school was: District A--36% mixed; District B--28% mixed; and District C--26% mixed. Of the students exhibiting mixed laterality preference, 17, or 56%, scored higher, although not 1.5 standard deviation units higher, on the Reading subtest than on the Mathematics Composite of the ITBS. See Appendix C.

Major Findings

Research Question #1

When a 1.5 standard deviation discrepancy rule was followed, only one child was classified as dsylexic (1%) and no dsycalculic (0%) children were identified. When defined in the manner described, the incidence of dyscalculia does not approach as much as 10% as Rubin (1990) quoted Rosenberger as having said in The Des Moines Register.

Research Question #2

Because there were no children meeting the criteria as defined by the study, in either category, dyscalculic or dyslexic, the question of whether laterality preference differed among dyscalculics as compared to dyslexics could not be addressed.

Minor Findings

Heuristic analysis revealed that in order to meet minimum cell frequency requirements for chi square analysis, the researcher had to revise the number of standard deviation differences required for designation as math deficient or reading deficient almost to a level where differnces could be accounted for by chance alone. Even when using a 1.0 standard deviation discrepancy rule, few children were identified in both categories. In fact, the researcher had to drop to a .66 and a .50 standard deviation difference in order to have enough subjects qualify for designation in either categories to adequately fill the cells of a chi square analysis. Results of the chi square analyses can be seen in Appendix B.

In order to determine whether the cause for our lack of findings were a result of the school district populations from which we sampled, the Reading subtest and the Math Composite class average national percentile ranks were obtained, after the conclusion of the study, for two of the three school districts. The third school district principal was unavailable so access to the data was denied. The class average percentiles for both fourth and fifth grades at both districts are reported in Table 3. Class averages for district A were (a) Grade 4--Math--31, Reading--72 (b) Grade 5--Math--65, Reading--77, and for district B (a) Grade 4--Math--96, Reading--84 (b) Grade 5--Math--94, Reading--82.

Table 3

School District Class Average Percentile Ranks

District	Grade	Reading	Math
A	4	72	31
A	5	77	65
B	4	84	96
B	5	82	94
C	UA	UA	UA

Note. Class average percentile information was not obtained for district C.

Data were reanalyzed for comparison of the numbers of children identified from each school as either dycalculic or dyslexic or neither based on the above criteria. It was found that the students fitting the criteria were evenly distributed among the three schools. Therefore, the difference in class averages between the two schools did not have much bearing on the number of kids identified from each school district. Raw data can be seen in Appendix C.

CHAPTER 4
DISCUSSION

Rubin (1990), wrote an article printed in The Des Moines Register in which a neurologist, Rosenberger, was quoted as saying that, "developmental dyscalculia is not as well known as dyslexia . . . but may be even more common . . . While dyslexia is thought to affect 3% to 5% of the population, dyscalculia might affect as much as 10% of the population" (p. T2). Related literature (Badian, 1983; Kosc, 1974) report lower numbers. Badian (1983) found that 6.4% of the sample studied experienced difficulty in mathematics, whether or not they had a disability. However, only 2.2% experienced difficulty in mathematics exclusively.

According to Mollen (1985), learning disabilities is one of the most controversial areas in special education today. Mollen stated that there is little agreement as to the definition, method of study, assessment and evaluation procedures, and remediation processes used among professionals. However, she goes on to say, that the label accounts for many of the children being served in special education in the United States. According to Mollen, 1,745,865 children, or 3.83% of the total U.S. school population, were receiving special education services during the 1982-1983 school year, under the learning disabled label (Mollen, 1985). The fact that only 3.83% of the total school population is learning disabled causes one to question the validity of the statement that "as much as 10% of the population may be dyscalculic" (Rubin, 1990). If 3.83% of the total population is learning disabled, it is unlikely that any one area of the disability would be as much as 10%. It follows that the parts must be less than the whole. If dyscalculia is in fact a learning disability in mathematics, as has been claimed here, than it is improbable that its incidence would be higher than that of the total population of identified learning disabled children. The implications of the controversy highlights the need for futher research in the area.

The results of the present study obtained from the three rural Iowa school districts do not approach the previoulsy reported figures (Rosenberger, 1989; Badian, 1983; Kosc, 1974). The incidence found for dyscalculia based on Rosenberger's (1989) 1.5 standard deviation disrepancy was 0% and that for dyslexia based on the same definition was 1%. Generalization of results from any of the above studies must be done with extreme caution as well as concern for the population involved. Rural populations differ in needs, resources, economics, politics, and other factors (Benson, 1985). School personnel, as well as parents who read the media, must be made aware of these differences before program demands are made and children are administered assessment batteries unnecessarily.

When a child fails to learn, professionals will seek to find the cause. Often educators are willing to accept the notion that the problem lies within the child. When a physician (Rosenberger, 1989) publishes an article providing a potential neurological cause to explain the dysfunction, educators can conclude that the problem does indeed lie within the child. Furthermore, they can assume that they need not look further to the curriculum or pedagogy for possible revision.

Rosenberger (1989) discussed that children with specific problems in math can be identified by mixed laterality preference, disorders of visouspatial learning, and attention disorders. He discussed a probable neurological cause of the three dimensions in the literature review section of his article. However, in the methodology section of the same article, he operationally defined dyscalculia and dyslexia as being based on the child's performance on the Key Math Diagnostic Arithmetic Test (KDMT) and the Woodcock Reading Mastery Tests (WRMT). He conducted a study with 102 children and adolescents referred to the Learning Disorders Unit of the Massachusetts General Hospital. Subjects meeting discrepancy criteria of a 1.5 standard deviation difference between their Mathematics Achievement Quotient and their Reading Achievement Quotient, with reading being above 100 and mathematics being below 100 were designated dyscalculic. The subjects meeting the converse criteria were designated dyslexic. There is nothing in the article to explain the definition shift. Personal correspondance with the author resulted in the receipt of a copy of the 1989 article. Consequently, Rosenberger's results from a study of how two groups identified as dyscalculic or dyslexic differ on a wide range of measures were based on a discrepancy definition and not an attribute definition.

Rosenberger (1989) used a known sample of already identified children and analyzed them on the basis of several measures to check which, if any, of the measures could distinguish between the two disabilities. In his study, it was reported that laterality preference differed significantly between those subjects designated as dyscalculic and those designated as dyslexic. That is, eye preference in sighting was discrepant from that for motor behaviors more frequently among children with dyscalculia than among children with dyslexia. Rosenberger found, in his clinic based sample, that, on the average, people prefer the same hand, foot and eye. However, the dyscalculic child is more likely to prefer their right hand and right foot, but prefer their left eye.

Due to the lack of children identified in each category (dyscalculic or dyslexic), the use of laterality preference as a discriminator between disabilities could not be analyzed. However, analysis of the data gathered revealed that 29% of the students included in the study exhibited mixed laterality preference. Furthermore, of the 30 students exhibiting the mixed preference, 56% of them scored higher on the Reading subtest than they did on the Mathematics Composite part of the ITBS. Due to the finding, further research in the area appears to be warranted.

Implications for Future Research

The results of the present study indicating that no children fit the criteria of a 1.5 standard deviation difference between a math score and a higher reading score for designation as dyscalculic was a surprise to the researcher. There are several possibilities as to the cause of the result. First, the school districts chosen for participation were not randomly selected from all of the Iowa school districts meeting the criteria for designation as rural. Nor were schools outside of Iowa used in this study. The sample did include three districts of similar size. However, the non-random sampling procedure may have caused the sample to be biased from the onset. This could be true due to possible differences in the curriculum or teaching methods employed in the school districts studied. The curriculum and teaching pedegogy could be better in the three districts studied than in other places, causing the students to perform better in the area of mathematics. Also, it is possible that the researcher serving a practicum experience in one of the school districts prior to the onset of the study could have biased the study, due to her possible involvement with the students prior to the beginning of the study. However, all of the students participating in the study were unfamiliar to the researcher. Also, the ITBS were administered after the conclusion of the researcher's practicum experience. It is not believed that the researcher had any effect on the results other than the effects that would be expected by normal administration of the Laterality Scale.

Another factor which may have caused the sample to have some elements of bias is related to the use of a parental permission form. See Appendix A. Only those students for whom permission forms were obtained were allowed to participate in the study. A return rate of 50% of the parental permission forms created limited access to students, causing the current sample size to be small and possibly unrepresentative of the school district, which may have created some bias in the results. For example, the children who's parents signed and returned the permission forms may have been significantly different from those students who's parents did not return the forms. It is possible, but unknown, that the parents, knowing that their child experienced difficulties in mathematics, did not wish them to be identified and so did not sign the form. A refusal of the sort described might have eliminated some of the students who exhibited the sought after discrepancy, causing it to appear that the incidence of the discrepancy was 0%. The researcher had no way of knowing whether significant differences existed in the students since records of the students not returning permission forms were not allowed to be included in the study. The limitation is difficult to address due to limitations set by the Human Subjects Review Board and informed consent. One possible manner of handling the problem might be to educate the parents more about the nature of the study prior to running it. The current researcher sent out one letter to the parents and offered to take any questions at home or at school. A parental meeting to discuss the study might have been helpful in obtaining more permission forms. The next researcher would be well advised to address the problem.

Class average percentile ranks were obtained after the conclusion of the study to determine whether the lack of findings could be explained by existing differences in the composition of the student bodies in the three districts. The researcher was only able to secure the information from two of the three schools included due to difficulties locating the principal of the third school. Differences between the two schools from which data were obtained did exist. The disrepancy between averages could account for some of the differences obtained. The students included from district B were more likely to score higher on the Math Composite subtests of the ITBS than they were on the Reading subtest than were the students involved from district A. Existing differences might have caused our distribution to show less children exhibiting the dyscalculia discrepancy than would have been observed in another sample from different school districts, thereby creating incidence results that are a function of those differences. However, a one-way Analysis of Variance of the normalized *z* scores yielded insignificant results by district, suggesting that differences between the school districts were not sufficient to account for differences in our data. Further analysis of the data suggested that the sample of students designated as either math discrepant or reading discrepant based on the criteria selected were evenly distributed across districts. Generalization should be limited to the school districts involved in the study. However, the information is valid since it suggests that individual districts do differ in composition, thus, results obtained from samples from other than that particular district should be used with discretion when planning and implementing curriculum changes.

Pearson Product Moment Correlations yielded a total group correlation of .72. The result suggests that the two scores, Mathematics Composite and Reading subtest, were related such that, finding a child who scored high in one area and 1.5 standard deviations lower in the other area would have been less likely than finding a child who scored high in both areas or low in both areas. However, the correlation accounts for only 51% of the total variance and leaves a major amount to be contributed by some other factor. The result could, therefore, account for some of the lack of children exhibiting the discrepancy. Cawley's (1985) statement that mathematics and reading achievement are related in that as reading achievement improves, so does mathematics achievement, supports the arguement that it may have been unlikely to have found very many children exhibiting the described discrepancy between their reading and mathematics ITBS scores.

Another factor which may account for the differences in the obtained results may be the difference in the achievement tests used to designate mathematics ability and reading ability. Rosenberger (1989) used two totally different individual standardized achievement tests, the Key Mathematics Diagnostic Test (KMDT) and the Woodcock Reading Mastery Test (WRMT), for the purpose of defining the child's achievement quotient. In the present study, the scores were taken from the Mathematics Composite and Reading subtest of the Iowa Tests of Basic Skills (ITBS), a group achievement test battery. The differences in the norming procedures and content validity of these could account for obtained differences. Data regarding the correlations between these tests reported correlations of .78 between the KMDT and the ITBS as well as between the WRMT and the ITBS (Connolly, Nachtman, &

Pritchett, 1971; Woodcock, 1973). However, it is possible that scores obtained on the KMDT and the WRMT are not comparable to scores obtained on the ITBS. The researcher could have learned this information had she given the individual tests to each child involved in the study and compared the scores on the individual tests to the one's earned on the group test and then compared the interrelations between the three tests. However, due to time and money constraints, the researcher chose not to do so. Further research addressing the correlations between the ITBS and the KDMT and WRMT respectively is needed and welcomed in the area.

Another area of concern is the fact that only one definition of dyscalculia was explored here. There are several other definitions that may be larger in scope and may therefore identify more students with the disabiltiy. The stringency of this definition could have limited the definability of the disorder. Future research could investigate other definitions and their ability to diagnose and identify those students experiencing difficulties in mathematics.

The future researcher might address the problem of the stringency of the definition designated by Rosenberger (1989) to label a dysfunction dyscalculic or dyslexic by lowering the discrepancy required to designate a label. However, the reader will note that the current researcher had to employ a .66 and a .50 standard deviation difference in order to find enough children who fit the minimum criteria cell frequency requirements for a chi square analysis. It is questionable whether such small discrepancies can identify a dysfunction or disability of any kind. It is possible that students who experience difficulty in mathematics do not achieve scores in mathematics which are 1.5 standard deviations below their average or above reading scores. The two disabilities may not be isolated events (Cawley, 1985). If a child has difficulty reading, it is possible that the child will have difficulty learning in other areas of the curriculum as well. Possibly learing disability is the global term of choice here, addressing all of the learning problems in one or more area of the curriculum. Also, it is possible that the the use of discrepancy between two different achievement scores as the designating criteria rather than the more often agreed upon definition of achievement versus intellectual potential, might not identify the children actually in need of services (Cawley, 1985). Possibly a more attribute based definition is needed. Future research could address the issue further.

Despite the difficulties discussed above, the researcher found it surprising that none of the children included in the study met the criteria for dyscalculia. The researcher desired to study laterality preference as a discriminator between dyscalculia and dyslexia as was demonstrated in Rosenberger's 1989 study. Rosenberger studied a known sample of previously referred students using a 1.5 standard deviation discrepancy difference between Mathematics Quotient and Reading Quotient to distinguish between the two groups. It was believed that since the disrepancy defined already referred students, it should be sufficient to pick up at least a few in a non-referred sample as well. The fact that no children met the criteria is important and should be kept in consideration for further research in the area of mathematics learning disability.

It is possible that the lack of children fitting the specified criteria for designation as dyscalculic or dyslexic in the current sample was caused by bias in the sample or differences between the districts included. At first glance, the data obtained for school districts A and B does exhibit some difference. However, when a one-way analysis of variance was ran by district, it yielded a non-significant F, suggesting that the differences were not enough to account for the lack of findings. Also, in a similar study ran concurrently on an urban population (Smith, 1991), similar results were obtained. If the lack of children fitting the criteria in the current study were a function of only the bias present in the sample, one would expect a study using a similar procedure to exhibit results more in line with what was expected. However, Smith found no children exhibiting the desired 1.5 standard deviation discrepancy difference either. The similar result suggests that the problem lies, not within the methodology or sampling procedure of the study, but within the stringency of the requirement for designation as either dyscalculic or dyslexic. Further research addressing the issue is encouraged.

Rosenberger was quoted as stating that it is possible that as much as 10% of the population may be affected by dyscalculia and from 3 to 5% may be affected by dyslexia (Rubin, 1990). Using a 1.5 standard deviation discrepancy rule for designation as dyscalculic and/or dyslexic, the incidence rates obtained in the current study did not approach as much as 10%. Although the current sample was small and had elements of bias as discussed above, it is obvious that Rosenberger's statement, as quoted by Rubin, cannot be generalized to the sample studied here.

It is important that professional educators be concerned and skeptical of claims made regarding incidence figures and quick screening procedures for identification of our students as learning disabled in whichever category. It is important that claims and statements be justified and verified on the population in question before one asks for and/or implements program changes and assessment procedures unnecessarily. The current study addressed one such issue. Does dyscalculia exist in as much as 10% of the population, and, if so can the disorder be distinguished from dyslexia by matter of laterality preference? The answer to the first question appears to be, not in the current sample, and not using the chosen definition of a 1.5 standard deviation discrepancy for identification. The answer to the latter question will have to wait since it could not be addressed in the present study due to lack of identification and designation of children as having either dyscalculia or dyslexia based on the discrepancy definition used. Further research is welcomed and encouraged in the area.

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APPENDIX A
PARENTAL PERMISSION FORM

In the next few weeks, students from the University of Northern Iowa will be conducting research in your child's elementary school building. The research will include students from the fourth and fifth grade classes and will involve looking at cummulative files. I would appreciate your consent to allow your child to participate in this project. Below is an explanation of the study that will be conducted and the extent of the participation requested of your child. Please read it carefully and return it signed by Monday, May 28, 1991. Your cooperation would be greatly appreciated.

There are two purposes to this study: (1) to examine the incidence of a math learning disability known as dyscalculia as it occurs in a rural school-age population; and (2) to discover whether children with mathematical disabilities differ from children with reading disabilities and the rest of their same aged peers in regards to their laterality preferences. Lateralization refers to the specialization of the hemispheres of the brain for various cognitive, perceptual, and motor or sensory activities. For example, what hand does the child write with, what arm does he/she throw with, etc. Whenever a child does not progress in a content area, educators become concerned. It is important to have effective and efficient assessment procedures that clearly distinguish between disorders. Identification of the incidence rate of this phenomenon in Iowa could lead to further study and more individualized instruction methods in the classroom. For those students involved, instructional methods aimed at preventing further mathematical difficulties could prove very beneficial. The data to be collected for this project will include scores obtained from previously administered Iowa Tests of Basic Skills (ITBS) and laterality preferences as obtained from a brief test to be administered on the playground. The ITBS is a standardized achievement test given statewide. Acquistition of these scores will involve looking at cummulative records. The researchers will look at ITBS scores only, and only with the written consent of the parents of the students involved. The laterality preference scale will consist of the following: first the examinier will ask the child to write his/her name on a piece of paper, next, he/she will ask the child to look at them through a hole punched in the paper, then crumple it up and toss it to the examiner, and finally the child will be asked to kick the piece of paper to the examiner. The examiner will note the preferred hand, eye, arm, and leg accordingly. This entire process will take about 1 minute per child and will be conducted on the playground during their usual recess time. The names of the children will be used only as long as the examiners are at the school for the sole purpose of comparing incidence and laterality preference. Once the data has been collected, the names will be removed and left at the school.

Your child's participation in this study is voluntary and if, at any time, you feel it is no longer beneficial for your child to continue participating, you may withdraw permission. Refusal to participate will not involve any penalty or loss of other benefits for which your child is entitled as a student at this school.

If there are any questions regarding this project, you may contact either the Graduate College at the University of Northern Iowa, (319) 273-2748, Karen Annis, or Dr. Donald Schmits, supervising professor, Department of Educational Psychology and Foundations, 273-2694.

I am fully aware of the nature and extent of my child's participation in this project as stated above and the possible risks arising from it. I hereby agree to participate in this project. I acknowledge that I have received a copy of this consent statement.

APPENDIX B
HEURISTIC CHI SQUARE ANALYSES

Table B-1

Theoretically Based Chi Square Analysis for Subjects with a .66 Standard Deviation Difference

Designation	Laterality Preference Mixed	Consistent	Totals
Dyslexia	5 (10.4)	7 (10.4)	12
Dyscalculia	3 (10.4)	6 (10.4)	9
	8	13	21

X^2 (1) = 11.1, $p < .0001$.

Table B-2

Standard Calculation Procedure Chi Square Analysis for Subjects with a .66 Standard Deviation Difference Between Scores

Designation	Laterality Preference Mixed	Laterality Preference Consistent	Totals
Dyslexia	5 (4.6)	7 (7.4)	12
Dyscalculia	3 (3.4)	6 (5.6)	9
	8	13	21

X^2 (1) = .142, $p < .75$, $p > .01$.

Table B-3

Theoretically Based Chi Square Analysis for Subjects with a .50 Standard Deviation Difference

Designation	Laterality Preference Mixed	 Consistent	Totals
Dyslexia	5 (10.4)	16 (10.4)	21
Dyscalculia	10 (10.4)	11 (10.4)	21
	15	27	42

X^2 (1) = 5.87, $p < .025$

Table B-4

Standard Calculation Procedure Chi Square Analysis for Subjects with a .50 Standard Deviation Difference Between Scores

Designation	Laterality Preference Mixed	Consistent	Totals
Dyslexia	5 (7.5)	16 (13.5)	21
Dyscalculia	10 (7.5)	11 (13.5)	21
	15	27	42

X^2 (1) = 2.592, $p < .25$.

APPENDIX C
RAW DATA

Code	Laterality	*z* Score Discrepancy	High	School District
01	NM	.68	R	1
02	NM	.37	M	1
03	NM	.83	R	1
04	NM	.20	R	1
05	NM	.57	R	1
06	M	.21	M	1
07	NM	.60	M	1
08	NM	.37	M	1
09	M	1.12	M	1
10	NM	1.47	M	1
11	M	.33	M	1
12	NM	1.91	M	1
13	NM	.13	M	1
14	NM	.47	R	1
15	M	.97	R	1
16	NM	.08	M	1
17	M	.74	R	1
18	NM	.08	R	1
19	NM	.08	M	1
20	M	.64	R	1
21	M	.28	M	1
22	NM	.00	SAME	1
23	NM	.11	R	1
24	M	.39	M	1
25	NM	.51	R	1
26	M	1.30	M	1

Code	Laterality	$\underline{z}$ Score Discrepancy	High	School District
27	NM	.23	M	1
28	M	.08	R	1
29	M	.38	R	1
30	NM	.03	M	1
31	NM	.28	R	1
32	NM	.11	R	1
33	NM	.40	R	1
34	M	.61	R	1
35	NM	.41	R	1
36	M	.04	M	1
37	M	.98	R	1
38	NM	.43	M	1
39	NM	.14	M	1
51	NM	.14	R	2
52	NM	.05	R	2
53	NM	.48	M	2
54	NM	.28	R	2
55	NM	.50	M	2
56	M	.44	R	2
57	NM	.55	M	2
59	NM	.33	M	2
60	NM	.60	M	2
61	NM	.49	R	2
62	NM	.09	R	2
63	M	.28	M	2
64	NM	.27	M	2
65	NM	1.49	M	2
66	M	.64	M	2
67	NM	.67	R	2
68	M	.00	SAME	2
69	M	.56	M	2
70	NM	.19	M	2
71	NM	.50	M	2
72	NM	.53	R	2
73	NM	.00	SAME	2

Code	Laterality	z Score Discrepancy	High	School District
74	NM	.57	M	2
75	M	.86	R	2
76	NM	.65	R	2
77	NM	.37	M	2
78	NM	.55	M	2
79	M	.17	M	2
80	NM	.12	R	2
81	NM	.49	R	2
82	NM	.53	R	2
83	M	.50	M	2
84	NM	.60	M	2
85	NM	.66	M	2
86	NM	.79	M	2
87	M	.76	R	2
88	NM	.26	R	2
89	NM	.17	R	2
100	NM	.00	SAME	3
101	NM	.05	R	3
102	NM	.33	M	3
103	NM	1.31	R	3
104	NM	.17	M	3
105	NM	.24	R	3
106	M	.38	R	3
107	NM	.57	R	3
108	NM	.37	R	3
109	M	.37	R	3
111	M	1.24	R	3
112	NM	1.16	M	3
113	M	.38	R	3
114	NM	.70	R	3
115	NM	.83	M	3
116	NM	1.32	M	3
117	NM	.18	M	3
118	NM	.57	M	3
119	NM	.09	R	3
120	NM	.28	M	3

Code	Laterality	*z* Score Discrepancy	High	School District
122	M	.27	R	3
123	NM	.40	M	3
124	NM	.29	R	3
125	M	.52	R	3
126	M	.52	R	3
127	NM	.29	R	3
128	NM	.06	R	3

Note. District A = 1; District B = 2; District C = 3.