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Emphasis on Adolescents and Young Adults

ANALYSIS OF COGNITIVE ABILITIES OF ADOLESCENTS LEARNING DISABLED SPECIFICALLY IN ARITHMETIC COMPUTATION

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Cooperating Agencies

Were it not for the cooperation of many agencies in the public and private sector, the research efforts of The University of Kansas Institute for Research in Learning Disabilities could not be conducted. The Institute has maintained an on-going dialogue with participating school districts and agencies to give focus to the research questions and issues that we address as an Institute. We see this dialogue as a means of reducing the gap between research and practice. This communication also allows us to design procedures that: (a) protect the LD adolescent or young adult, (b) disrupt the on-going program as little as possible, and (c) provide appropriate research data.

The majority of our research to this time has been conducted in public school settings in both Kansas and Missouri. School districts in Kansas which are participating in various studies include: United School District (USD) 384, Blue Valley; USD 500, Kansas City; USD 469, Lansing; USD 497, Lawrence; USD 453, Leavenworth; USD 233, Olathe; USD 305, Salina; USD 450, Shawnee Heights; USD 512, Shawnee Mission, USD 464, Tonganoxie; USD 202, Turner; and USD 501, Topeka. Studies are also being conducted in Center School District and the New School for Human Education, Kansas City, Missouri; the School District of St. Joseph, St. Joseph, Missouri; Delta County, Colorado School District; Montrose County, Colorado School District; Elkhart Community Schools, Elkhart, Indiana; and Beaverton School District, Beaverton, Oregon. Many Child Service Demonstration Centers throughout the country have also contributed to our efforts.

Agencies currently participating in research in the juvenile justice system are the Overland Park, Kansas Youth Diversion Project and the Douglas, Johnson, and Leavenworth County, Kansas Juvenile Courts. Other agencies have participated in out-of-school studies--Achievement Place and Penn House of Lawrence, Kansas, Kansas State Industrial Reformatory, Hutchinson, Kansas; the U.S. Military; and the Job Corps. Numerous employers in the public and private sector have also aided us with studies in employment.

While the agencies mentioned above allowed us to contact individuals and supported our efforts, the cooperation of those individuals--LD adolescents and young adults; parents; professionals in education, the criminal justice system, the business community, and the military--have provided the valuable data for our research. This information will assist us in our research endeavors that have the potential of yielding greatest payoff for interventions with the LD adolescent and young adult.

ABSTRACT

A major problem with the definition of learning disabilites is the paucity of research addressing the two major componets of the definition, i.e., task failure and psychological processes. Addressing the two above definitional components, the purpose of this investigation was to identify a group adolescents homogeneously defined as exhibiting a "specific learning disability in arithmetic" and to determine if the cognitive processes: visual-spatial, visual-reasoning, and visual-memory are related to the academic task failure exhibited by this population. The following hypothesis was tested: There is no difference among the three groups, SLD-ARITH, SLD-READ, and AVE-ACH on visual-spatial, visual-reasoning, and visual-memory tests.

Three groups of students participated in this investigation. The experimental group, SLD-ARITH, was defined as seventh-, eight-, and ninth-grade learning disabled students whose arithmetic computation achievement grade level was two or more grades below their word recogi-nition grade level. Of the two contrast groups participating in the study, the first, SLD-READ, consisted of seventh-, eighth-, and ninth-grade learning disabled students whose word recognition achievement level was 1½ or more grades below their arithmetic computation level. A second contrast group of average achieving students, AVE-ACH, was defined as seventh-, eighth-, and ninth-grade students attending regular classes who were perceived by their teachers as average achievers.

Subjects in all three groups were administered six cognitive instruments representing the areas of visual-spatial, visual-reasoning, and visual-memory. Four subtests were selected form the Woodcock-Johnson Psycho-Educational Battery: Visual-Matching, Spatial-Relations, Analysis-Synthesis, and Concept-Formation. The other two subtests were taken from the Revised Test of Visual Retention, Benton Copying and Benton Memory.

The results of this study indicate that there is a relationship between two of the major components in the learning disabilities definition, academic task failure and specific cognitive abilities. There is validity to the above two components of the LD definition when a very specific population of students disabled in arithmetic have been identified.

ANALYSIS OF COGNITIVE ABILITIES OF ADOLESCENTS LEARNING DISABLED SPECIFICALLY IN ARITHMETIC COMPUTATION

The field of learning disabilities (LD) has grown so rapidly that the research base for this population has not been clearly established. As a result the LD definition has evolved from an unsound research foundation. In addition several other factors have contributed to the problems of definition. The positive connotation of the learning disabilities label, as opposed to that of mental retardation, has impelled parents to seek LD services rather than other programs for exceptional children (Ringelheim, 1978). Students who did not fit traditional categories of exceptionality have now been placed in programs for the learning disabled, as have students previously called "underachievers." Now LD programs comprise a heterogenous population. Senf (1978) described LD programs as serving students on the basis of academic difficulties rather than disabilities. What began as services for students with severe learning problems have now often become services for underachievement as well (Drozda, 1976). Services to students with disabilities in arithmetic, listening, writing, spelling, and thinking have generally been overshadowed by remedial reading.

An attempt to clarify the LD definition should begin with research validating the association between the two major components of the LD definition, i.e., academic task failure and psychological process disabilities. A greater understanding of each separate component, as well as their interaction, is needed to operationalize the definition. The LD definition specifically lists the following areas of academic

task failure: listening, thinking, speaking, reading, writing, spelling and mathematical calculations. Although seven academic areas are listed, reading has received the most attention.

In contrast the LD definition does not specifically list the psychological processes. In reviewing the literature, some of the following psychological processes have been associated with the learning disabled: visual, auditory and haptic perception, attention, discrimination, memory, sensory integration, concept formation, and problem solving. The definition cites a disorder in one of the psychological processes as the basis for the inability to perform academic tasks. However, difficulty in measuring and defining psychological processes has been a barrier in operationalizing the process component for identification and research purposes (Chalfant & King, 1975). Therefore a research priority in the field of learning disabilities should be to investigate the association between psychological processes and specifically defined academic task failures. In addition, research is needed in the academic task failures which have been ignored, e.g., arithmetic.

Insight into defining a specific arithmetic learning disability can be obtained by empirically and systematically investigating the cognitive processes that have been associated with an arithmetic disability. Three areas of the learning disabilities field have yielded relevant findings: work with severe mental defectives, perceptual motor theorists, and contemporary LD research.

Early work with populations studied in clinics and hospitals investigated characteristics of individuals with severe mental disabilities. The terminology was medical and anatomical; it described losses in ability to communicate, write, compute, think, etc., which

resulted from neurological system dysfunctions. Physicians, describing patients with such characteristics, contributed a majority of the work. Henschen, Strauss, Werner, Gustman, and others studied adults and some children with severe mental deficits. Many of their measures were perceptual. Their major contribution to research was in describing studies of individuals with severe observable characteristics. Individuals with specific disabilities in arithmetic computation were found to have finger agnosia, visual-spatial problems, memory difficulties, and lack of understanding for the operations.

During the second era, the field tried to determine the perceptual and cognitive correlates of a learning disability. Research shifted from medical perspective to educational manifestation of perceptul disabilities. However, the theory of a neurological basis for the disability prevailed: "The work of Barsch, Frostig, Getman, Kephart, Cruickshank have posited that LD is the result of perceptual problems based on the neurological system' (Vellutino, Steger, Hardig, & Miles, 1977). The impact of this era is the persistent conclusion that the psychological-process components should be interpreted within the context of perceptual deficits (Mercer, Forgnone, & Wolking, 1976).

The third era, a contemporary phase of the LD field, has only begun to investigate the cognitive processes associated with a specific arithmetic disability. Studies by Cawley, Kosc, and Slade have identified visual-spatial and reasoning ability as correlates of an arithmetic disability.

Research during these three areas with indiviudals disabled in arithmetic has repeatedly reported difficulties in visual-spatial, memory, and reasoning cognitive processes as associated characteristics.

The purpose of this investigation was to identify a group of students homogeneously defined as exhibiting a "specific learning disability in arithmetic" and to determine if the cognitive processes: visual-spatial, visual-reasoing, and visual-memory are related to the academic task failure exhibited by this population.

If there is an association between the two components of the LD definition, i.e., psychological processes and academic task failure, disabilities in specific processes will result in certain academic task failures. The processes involved in the task failures of arithmetic and reading will differ. Therefore, students "specifically disabled in arithmetic calculation", students "specifically disabled in reading word recall", and normally achieving students were compared in the above cognitive areas.

Methods

Subjects

The three research groups were defined as follows:

"Specifically learning disabled in arithmetic" (SLD-ARITH), seventh-, eighth-, and ninth-grade learning disabled students whose arithmetic computation achievement grade level is two or more grades lower than their word recognition grade achievement level.

A contrast group of students was defined as:

"Specific learning disability in reading" (SLD-READ), seventh-, eighth-, and ninth-grade learning disabled students whose word recognition achievement level is 1½ or more grades lower than their arithmetic computation level.

A second contrast group of average achieving students was defined as

follows:

Average achievers (AVE-ACH), seventh-, eighth-, and ninth-grade students attending regular classes who are perceived by their teachers as average achievers.

In order to identify the two groups of learning disabled students exhibiting specific discrepancies, a large number of schools were asked to participate in the study. Forty-three junior-high schools from the Kansas City, Kansas, and Kansas City, Missouri school districts as well as from school districts in a 70-mile radius from Kansas City participated.

Learning disabilities teachers from the forty-three schools volunteered to participate in identifying candidates for the two LD groups. In cooperation with the LD teacher, candidates for the study were identified on the basis of IQ, arithmetic and reading scores from test records, and school files. Students were required to meet the following criteria:

1. Currently receiving special services and labeled learning disabled by the school district.

2. Exhibiting an IQ above 80 on a standardized intelligence test.

3. Not receiving special services or labeled as emotionally disturbed.

4. On any previously administered arithmetic and reading achievement test, e.g., Wide Range Achievement Test (WRAT), Peabody Individual Achievement Test (PIAT), Key Math Diagnostic Arithmetic Test (Key Math), and Woodcock Reading Mastery Test, exhibiting one of the following:

(a) arithmetic achievement score two grades or more below reading achievement score (SLD-ARITH), (b) reading achievement score two grades or more below arithmetic achievement score (SLD-READ). In either case, the lower of the two tests had to be below fifth grade to ensure that the student actually evidenced a specific disability.

Because of the large variance found on the above arithmetic and reading tests, students meeting the above criteria were retested with the WRAT so that all students would be considered for final selection on the basis of uniform test scores.

Thirty students from the SLD-ARITH pool and 30 students from the SLD-READ pool were chosen on the basis of the WRAT scores. The 30 students with the largest discrepancies between their arithmetic and reading scores were chosen. Because of smaller discrepancies found in the SLD-READ group, students with discrepancies smaller than 2.0 had to be included.

The students in this group represented a "specific learning disability in either arithmetic or reading." They represented 2% of the approximate 29,670 total enrollment of regular class students attending the 43 junior high schools and 5.3% of the LD population attending the schools.

The third group, AVE-ACH, was randomly selected from four schools which also had LD students participating in the study. Approximately the same number of seventh-, eighth-, and ninth-graders were chosen as in the two LD groups. Within each school, a teacher or guidance counselor selected the students according to the following criteria:

1. The teacher or counselor perceived the student as an average achiever in school.

2. The teacher or counselor perceived the student to be of average intellectual ability.

3. The teacher or counselor did not perceive the student as handicapped.

Description of Subjects

Descriptive data are provided for the thirty students in each of the three groups.

Age and grade. The mean ages and grades of the three groups were analyzed using an F-test for independent means. No differences were obtained across the three groups in age and grade level using an F-test for independent means. Table 1 lists these values.

Insert Table 1 about here

WRAT arithmetic and reading. Arithmetic and reading WRAT scores were available for students in all three groups. Project staff administered the WRAT to the students in the AVE-ACH group. Table 2 tests the F-values obtained for comparison on mean arithmetic scores, mean reading scores, and mean discrepancy scores. Significant differences across groups were obtained on WRAT arithmetic, reading, and discrepancies as expected; the SLD-ARITH group was lowest in arithmetic and SLD-READ group lowest in reading.

Insert Table 2 about here

The mean discrepancy of the SLD-ARITH group was larger than the mean discrepancy of the SLD-READ group. In addition, the AVE-ACH group also exhibited an unexpected discrepancy with arithmetic being lower than reading. The range of discrepancies for the SLD-ARITH group was 8.8 to 2.5. The SLD-READ group's discrepancies ranged from 4.6 to 1.6.

A significant difference was found between the arithmetic and reading discrepancies across the three groups. An individual analysis of the WRAT arithmetic and reading scores was performed in order to clarify the differences

among the mean discrepancies. The mean actual grade placement level of the AVE-ACH students was 7.70. In comparing their grade placement level to their mean WRAT arithmetic and reading scores, the following values were obtained: 7.31 in arithmetic and 8.86 in reading. These achievement levels are not congruent with their grade placement. The arithmetic score was .39 grade levels below their grade placement while the reading score was 1.16 higher than grade placement. This discrepancy may be an artifact of the test. It appears that reading scores are inflated and that arithmetic scores are slightly lower.

Grade level inequalities of the arithmetic and reading subtests would affect the discrepancy magnitudes of the SLD-ARITH and SLD-READ groups. Higher reading scores would lower the SLD-READ discrepancies in that the lower academic scores in reading are inflated. Conversely, the SLD-ARITH would increase the reading and arithmetic discrepancy.

Total IQ. Different IQ tests had previously been adminstered to the groups. Subjects had scores on at least one of the following instruments: WISC or WISC-R, Stanford-Binet, Slosson, DAT, PPVT, Lorge-Thorndike, Otis Lennon, and SRA-STEA. The mean IQs of the three groups were compared using an F-test for independent means. In addition, a T-test was computed for the mean IQ of the two LD groups. The values are shown in Table 3.

Insert Table 3 about here

A significant difference was found in IQs among all three groups. However, no difference was found between the two LD groups. The literature

supports the findings that LD students have lower IQs than regular class students (Smith, Coleman, Dokecki, & Davis, 1977).

Instrumentation

Four subtests from the Woodcock-Johnson Psycho-Educational Battery, Cognitive Tests (1978), Spatial-Relations, Visual-Matching, Analysis-Synthesis, and Concept-Formation together with two different administrations of the Revised Visual Retention Test (Benton, 1974) were administered according to standardized procedures. The subtests will be discussed separately for each with the following aspects described: test behavior required, test format, test reliability, and test standard error of measurement.

Spatial-Relations Subtest 1 (Woodcock-Johnson)

Subjects were required to select from a series of shapes the component shape needed to make a whole shape. The shapes become progressively more abstract and complex. The test is both a timed and a power test. A three-minute time limit was employed.

Visual-Matching Subtest 2 (Woodcock-Johnson)

Subjects were required to identify and circle two identical numbers in a row of six. Visual-matching is both a timed and a power test. A two-minute time limit was employed. The tasks become more difficult, beginning with single-digit numbers and ending with five-digit numbers.

Analysis-Synthesis Subtest 3 (Woodcock-Johnson)

Subjects were required to analyze the components of an equivalency statement and reintegrate them to determine the components of a novel equivalency statement. Correct and incorrect feedback is provided throughout the beginning and middle portions of the subtests. The test

is in part a learning task in which new concepts are presented and explained. Items are arranged in increasing levels of difficulty.

Concept Formation Subtests 4 (Woodcock-Johnson)

Subjects were required to identify one of four rules which separates examples of concepts from noninstances of concepts. The items are in a form similar to Boolean algebraic equations and arranged in order of difficulty.

Benton Copying Subtest 5 Form C

Subjects were required on Form C Administration C to copy 10 5½ x 8½ geometric designs which became progressively more difficult. There was no time limit on the exposure of the design. A student received a score of one for each design correctly copied. Scoring procedures are listed in the manual. One project staff member scored all the Benton subtests. A reliability check revealed 94% agreement.

Benton Memory Subtest 6 Form D

Subjects were required on Form D Administration D to view a geometric design for 10 seconds and after a 15second delay reproduce the design from memory. A memory-for-design score was obtained by subtracting the reproduction score on Administration D from the copying score on Administration C. The difference score (discrepancy between Administration C Administration D) represented the loss of points attributed to the added task of encoding and retrieving the design from memory.

Results

Scores from the three research groups on the six cognitive tests were analyzed using a multivariate analysis of variance program by Finn (1979). An overall F value of 6.24 was obtained, indicating that there

were significant differences among the three groups, across the six dependent variables analyzed simultaneously. The F value was significant at the .0001 level. A true difference among the three research groups was found across the set of cognitive variables. As part of the Finn program, univariate analyses were performed on the six cognitive variables to identify where the true differences were found. Table 4 lists the means and standard deviations of the six dependent variables for each of the three groups.

Insert Table 4 about here

The means of all three groups across the six cognitive variables were first analyzed. Significant differences between group means were found on the two visual-spatial subtests, Visual-Matching and Spatial-Relations, and one of the reasoning subtests, Analysis-Synthesis. Table 5 lists the univariate F values obtained on each of the dependent variables.

Insert Table 5 about here

Significant differences were found on three of the variables: Visual-Matching, Spatial-Relations, and Analysis-Synthesis. The AVEACH group had the highest means on each of the first four dependent variables. The SLD-ARITH had the lowest means and the SLD-READ scored between these groups on the first four variables.

A discriminant analysis was performed to determine the unique relationship among the dependent variables which existed when

classifying the group membership of the subjects. The standardized discriminant weights that were provided by the MANOVA are given in Table 6.

Insert Table 6 about here

Visual-Matching, Spatial-Relations, and Analysis-Synthesis received high weights and contributed most to group separation. The discriminant weights for all six variables comprised two discriminant equations. An individual can be classified into one of the three groups by entering all the subject's scores in these equations. Figure 1 contains the plot of the obtained discriminant equations.

Insert Figure 1 about here

Individuals in the SLD-ARITH are located on one extreme and AVE-ACH students toward the other extreme. SLD-READ students are placed within the middle of the continuum. Discriminant mean centroid scores reveal this separation. The SLD-ARITH mean discriminant score was 1.15; SLD-READ, .07; and AVE-ACH, 1.22.

A BMDP7M stepwise discriminant analysis program was also employed. This separate discriminant analysis program provided additional information pertaining to which dependent variables were significantly contributing to group classification. F values greater than 3.0 to enter and 3.0 to remove were analyzed in the stepwise program. With 90 individuals an F value of 3.0 represents a 10% level of significance. This level of significance was chosen to test the entrance and removal

of variables in the discriminant analysis. An F value of 3.0 allows variables in the equation which reasonably add to group classification. These values should not be confused with the F value for the overall discriminant analysis which was set at the .05 level. Table 7 lists the discriminant F values.

Insert Table 7 about here

With four variables in the discriminant function, 67.8% of the subjects were correctly classified. Table 8 lists these values.

Insert Table 8 about here

Twenty of the thirty SLD-ARITH were correctly identified. Of those misclassified, eight were categorized as SLD-READ students. Sixteen of the SLD-READ students were correctly identified, with seven misclassified as SLD-ARITH and seven AVE-ACH. The highest group correctly identified was AVE-ACH with 25.

The three groups scored differently on visual-matching, spatial-relations, and analysis-synthesis with highly significant univariate F statistics. The discriminant analysis indicated that these dependent variables were uniquely able to differentiate among the three groups.

Table 9 lists a correlation table for all three groups on the six dependent variables and IQ.

Insert Table 9 about here

All but five of the correlations were significant at the .05 confidence level. The MANOVA program does analyze variables when a dependent relationship exists. The relationship among IQ and the dependent variables suggests that IQ could have been a possible covariate.

The significance of IQ as a covariate was determined by reanalyzing the test results with a MANOVA and discriminant analysis employing IQ as a covariate. Table 10 lists these values.

Insert Table 10 about here

The overall F of 3.81 was still significant at less than the .001 level. The univariate F values were not reduced, and the discriminant weights remained in the same proportion and magnitude. It was concluded that IQ as a covariate did not affect the common mean structure across the variables.

Further analyses were conducted to perform two orthogonal contrasts. First, both SLD-groups were combined and compared to the control group. In a second contrast, the two SLD-groups were compared. These analyses were a pooled within-sums of squares error matrix for all three groups.

When groups of learning disabled students are specifically defined in terms of one academic task failure, arithmetic, an associaton with low performance in cognitive processes was found. The effects of IQ as a covariate did not affect this association.

Additional analyses were performed to compare the LD groups combined with the AVE-ACH group. Significant differences were found on five of the cognitive variables, both visual-spatial, both reasoning, and Benton Copying. The differences were largest on the same three subtests found

to be significant in the previous analysis, Visual-Matching, Spatial-Relations, and Analysis-Synthesis. Significant differences were also found on Concept-Formation and Benton Copying. In general, cognitive differences were found between learning disabled students with a severe, specific, academic deficit and average achieving students. Regardless of specific area, students with a severe academic deficit did exhibit cognitive problems. When IQ was covaried, differences between the SLDs and AVE-ACH remained on only three of the subtests, i.e., the two visual-spatial and analysis-synthesis subtests.

In a third comparison the scores of the two LD groups were compared. The Finn MANOVA program was employed in the "simple contrast" of SLD-ARITH = SLD-READ. When all six dependent variables were simultaneously analyzed across the two groups, a significant overall F of 3.42 was obtained. This value is significant at the .004 level. Table 11 lists the univariate F values which were obtained by individually comparing the two groups on each dependent variable. The error term used in the MANOVA analysis was pooled across all three of the original groups.

Insert Table 11 about here

The SLD-ARITH and SLD-READ groups means differed significantly on three dependent variables. THE SLD-READ group had higher scores on all three. The largest mean difference was obtained on the Analysis-Synthesis subtest.

A discriminant analysis was employed to determine the unique relationship among the dependent variables which existed when classifying the group membership of the subjects. The Finn multivariate program provided the dis-

criminant weights for all six dependent variables. Table 12 lists these values. The largest weight is given to the Analysis-Synthesis dependent variable. Scores on this variable to a large extent determine SLD-ARITH and SLD-READ group membership. The two other variables which had weights in the same direction were Visual-Matching and Spatial Relations. These findings are congruent with those obtained from the univariate analysis. Each of the three values significant in the univariate analysis are uniquely discriminating between the two groups and in about the same magnitude as their univariate Fs. In addition, the discriminant analysis revealed that Concept-Formation received a high weight in the opposite direction of the above three variables. This would indicate that concept formation has acted as a suppressor to Analysis-Synthesis because of their shared variance. The larger the difference between an individual's score on these two subtests, the greater the accuracy of classifying group membership.

Insert Table 12 about here

A BMDP7M discriminant analysis stepwise program was also employed. Only F values greater than 3.0 to enter the discriminant function were analyzed in the stepwise program. Two values significantly entered the second step of the discriminant program. Table 13 lists the values from the stepwise discriminant program. Only two variables entered the discriminant equation with an F value greater than 3.0, Analysis-Synthesis and Visual-Matching.

Insert Table 13 about here

With two variables in the equation, 71.7% of the individuals were correctly classified into their respective groups. Table 14 lists the classification matrix showing the number of individuals from each group classified as SLD-ARITH and SLD-READ. Twenty-one of the SLD-ARITH students were correctly classified in their group and nine were classified as SLD-READ. Twenty-two of the SLD-READ students were correctly classified and eight were misclassified as SLD-ARITH.

Insert Table 14 about here

A second analysis was conducted with IQ as a covariate. Neither the MANOVA univariate Fs or discriminant weights were significantly affected.

Discussion

Several comparisons were possible because of the unique definition used to select the three research groups: First, the SLD-ARITH groups was identified because of a unique deficit specifically related to arithmetic computation. They were achieving high in reading. Second, the SLD-READ group was disabled specifically in reading word recognition. They were achieving high in arithmetic. Essentially, both SLD-groups were achieving high expect in one designated area. Third, in contrast, the AVE-ACH group was achieving high in all areas. Therefore, when all three groups are compared, the essential difference among them lies only in the specific academic task failure of the SLD-groups. Thus, if the SLD-ARITH and AVE-ACH groups are compared, the major difference is that SLD-ARITH students are poor in arithmetic. Any differences found on

cognitive measures can be attritubed to their difference achievement in arithmetic. Likewise, when the SLD-ARITH and SLD-READ groups are compared, poor cognitive scores exhibited by the SLD-ARITH group can be attributed to the major difference between groups; the SLD-ARITH group performs poorly on arithmetic. By specifically defining the research groups, several specific comparisons were possible.

Analysis 1

When the means of all three groups were compared across the six cognitive variables, results from the MANOVA program indicated that significant differences existed across the three groups. Significant differences between group means were found on the two visual-spatial subtests, Visual-Matching and Spatial-Relations, and one of the reasoning subtests, Analysis-Synthesis. These results indicate that when research groups were specifically defined in terms of academic task failure and compared to average achievers, differences on psychological process variables existed. The students in the SLD-ARITH group performed lowest on the two visual-spatial tasks and one reasoning task, Analysis-Synthesis. The mean of the SLD-ARITH group was also lowest on concept formation. In addition, the SLD-READ group was lower than the AVE-ACH group.

The results indicate that an association exists between poor performance on the three cognitive subtests, Visual-Matching, Spatial-Relations, and Analysis-Synthesis, and a specific disability in arithmetic computation. Poor performance on these cognitive subtests was associated to a lesser extent with a specific problem in word recognition. Average achievers obtained high scores in arithmetic, reading, and the three cognitive subtests.

When groups of learning disabled students are specifically defined in terms of one academic task failure, arithmetic, an association with low performance in cognitive processses was found. The effects of IQ as a covariate did not affect this association.

Analysis 2

When the means of SLD-groups were compared to the AVE-ACH on the six dependent variables, significant differences were found on five of the cognitive variables, both visual-spatial, both reasoning, and Benton Copying. The differences were largest on the same three subtests found to be significant in the previous analysis, Visual-Matching, Spatial-Relations, and Analysis-Synthesis. Significant differences were also found on Concept-Formation and Benton Copying. In general, cognitive differences were found between learning disabled students with a severe, specific, academic deficit and average achieving students. Regardless of specific area, students with a severe academic deficit did exhibit cognitive problems.

Analysis 3

When the means of the SLD-ARITH groups were compared to those of SLD-READ across the six dependent variables, significant differences were found. The definition of learning disabilities specifies areas of academic task failure according to which a student may qualify as learning disabled. Two of these areas were investigated in the third analysis, a comparison of LD students disabled in arithmetic and LD students disabled in reading. The results indicate that on three cognitive subtests, the SLD-ARITH group performed significantly lower than the SLD-READ group. The largest difference was found on the Analysis-Synthesis subtest. Reasoning involving equivalency statements and reintegration appears to

be more difficult for students with a specific difficulty in arithmetic computation.

The results from the discriminant analysis revealed that the Visual-Matching and the Analysis-Synthesis subtests discriminated between the two groups with 71.7% accuracy. When students are specifically defined in terms of academic task failure, the cognitive component of the definition was substantiated.

Discussion Summary

Significant differences were found for each of the three research questions; likewise, significant differences were found on some of the cognitive measures. These findings were obtained for several reasons. First, the learning disabled groups represented students with a severe academic task failure. Forty-three junior-high schools had been surveyed to identify the thirty students in each SLD-group. In contrast, much of the past research with learning disabled students simply took intact groups of students and compared them to control or contrast groups.

Second, the SLD-students had a disability in one specific area while their functioning in other academic areas, i.e., arithmetic or reading, was discrepantly higher. Therefore, the two SLD groups were disabled in different areas, single task dimension, high or low arithmetic achievement. The SLD-ARITH group performed poorer on three cognitive measures. Since both the SLD-READ and AVE-ACH groups scored high in arithmetic, the difference between the cognitive measures can be attributed to the arithmetic variable.

Third, the review of literature specifically sought out the component variables which were highly related to arithmetic ability and disability. These cognitive variables, which were shown to be related to both academic areas were not included. As a result, the findings indicated that the

SLD-ARITH group was significantly lower on these variables. Visual-spatial and reasoning tasks were related to arithmetic achievement, whereas, memory and visual-motor ability were not.

Educational Implications

This investigation dealt directly with the following components of the USOE definition of learning disabilities. The first component, academic task failure, was employed to define LD students with either a severe arithmetic or reading difficulty. The second component, psychological or cognitive processes, was represented by several tests administered to the research groups.

Task Failure

Much of the research involving learning disabled students has been conducted with poorly defined research samples. Often intact classes of LD students have been considered as a homogeneous group in research studies. This problem is perpetuated by the lack of consistency in interpreting the USOE definition of learning disabilities.

This investigation has demonstrated the existence of significant cognitive differences between students with a "specific disability in arithmetic computation" and students "specifically disabled in reading work recognition." The LD populations should be specifically defined in terms of academic and cognitive difficulties. The term "specific learning disability" in the USOE LD definition can no longer be represented by intact classes of students exhibiting a vague range of academic difficulties.

Cognitive Processes

The results of this investigation have demonstrated that an association between specific academic task failures and poor scores on

cognitive tests exists. This relationship indicated that low scores in arithmetic achievement on any LD student are accompanied by low scores in three areas of cognitive ability.

The design of this experiment did not address the role of cognitive abilities in the acquisition of arithmetic skills. Although an association was found, it cannot be deduced that those cognitive skills are prerequisites for arithmetic achievement. Several other alternative hypotheses may exist. For example, the cognitive abilities may represent a separate component of a general arithmetic ability and, therefore, although not prerequisites, coincide with low computation achievement.

Regardless of which hypothesis proves to explain the exact nature of the relationship between cognitive difficulties and arithmetic achievement, several implications are relevant for educational interventions.

Ideally, the choice of educational intervention should be based on firm research. In reality, however, implementation of cognitive and psycholinguistic interventions in special education have not been based on research findings. As a result, many of the programs and interventions have not clearly produced significant educational gains. One of the reasons for this dilemma stems from the rapidly expanding need for LD services. Often, educational decisions cannot be delayed in anticipation of definitive research findings. Presently, for example, interventions are needed for students disabled in arithmetic computation. While definitive results regarding the relationship of cognitive processes and arithmetic are not available, the advocacy of particular interventions can be further supported.

Two interventions appear to hold potential for students with arithmetic computation problems. Since their cognitive scores in three areas were consistently low, strengthening or compensating for these deficits represents potential interventions.

In particular, interventions which compensate for cognitive difficulties of older students may aid these students in acquiring arithmetic computation skills. For example, when introducing new arithmetic concepts or remediating skills of students exhibiting cognitive deficits such as visual-spatial or visual-reasoning, these cognitive weaknesses can be compensated for. Cognitive visual abilities can be compensated for by presenting skills through concrete, three-dimensional aids. While a student may have difficulty reasoning with visual symbols, concrete aids may serve as a vehicle to enhance acquisiton of arithmetic skills. A second approach, the learning strategies approach, provides students with cognitive strategies to self-employ in learning new concepts. Students may employ techniques, rules, procedures to compensate for their individual cognitive deficits (Alley & Deshler, 1979).

The exact nature of the cognitive-academic relationship should be further investigated. In addition, the results from interventions in arithmetic which train or compensate for cognitive skills are also areas for further research. The interface between research and educational intervention must continue to further define the relationship between cognitive and academic areas.

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Table 1
Mean Ages and Grades of SLD-ARITH, SLD-READ, and AVE-ACH

Group	Mean	Standard Deviation	F
	Age		
SLD-ARITH	13.90	.78	1.59
SLD-READ	14.11	1.16	
AVE-ACH	13.66	.97	
	Grade		
SLD-ARITH	7.83	.59	3.91
SLD-READ	7.80	.84	
AVE-ACH	7.70	.79	

*P < .05.
**P < .01.

Table 2
F-Test SLD-ARITH, SLD-READ, and AVE-ACH on the WRAT

Group	Mean	Standard Deviation	F
	WRAT Arithmetic		
SLD-ARITH	3.63	.87	47.88**
SLD-READ	6.02	1.08	
AVE-ACH	7.31	2.15	
	WRAT Reading		
SLD-ARITH	7.80	1.83	84.45**
SLD-READ	3.56	.95	
AVE-ACH	8.86	2.02	
	Discrepancy		
SLD-ARITH	4.16	1.51	25.57**
SLD-READ	2.51	.72	
AVE-ACH	2.02	1.28	

*P < .05.
**P < .01.

Table 3
F-Tests for Mean IQs Across
SLD-ARITH, SLD-READ, and AVE-ACH

Group	Mean	Standard Deviation	
	All 3 Groups		F-value
SLD-ARITH	94.2	9.90	17.78**
SLD-READ	95.2	8.01	
AVE-ACH	108.76	13.08	
	SLD-ARITH and SLD-READ		F-value
SLD-ARITH	94.2	9.90	.102
SLD-READ	95.2	8.01	

*$P < .05$.
**$P < .01$.

Table 4
Means and Standard Deviations of Cognitive Measures

Dependent Variable	SLD-ARITH Mean	SLD-ARITH S.D.	SLD-READ Mean	SLD-READ S.D.	AVE-ACH Mean	AVE-ACH S.D.
Visual-matching	17.50	±2.63	19.10	±2.10	22.0	±2.91
Spatial-relations	38.70	±5.57	42.40	±6.15	48.50	±6.92
Analysis-Synthesis	16.40	±4.40	19.70	±3.01	21.60	±4.38
Concept-Formation	15.90	±6.14	16.40	±4.28	19.30	±7.43
Benton Copying	8.60	±1.40	8.43	±1.85	9.13	±1.07
Benton Discrepancy	2.93	±2.01	2.10	±2.05	2.33	±1.74

Note. All groups N=30.

Table 5
Univariate F Tests for 6 Dependent
Variables Comparing the SLD-ARITH, SLD-READ, and AVE-ACH

Dependent Variable	Mean Square	Univariate F
Visual-Matching	156.1	24.08***
Spatial-Relations	739.2	18.98***
Analysis-Synthesis	205.3	12.91***
Concept Formation	101.6	2.70
Benton Copying	4.0	1.80
Benton Discrepancy	5.5	1.40

Multivariate overall F 6.24***
*P<.05.
**P<.01.
***P<.001.

Note. All groups N=30.
Degrees of freedom for all dependent variables = 2/87.

Table 6
Weights for First Canonical Variate
All Six Dependent Variables in
Discriminating SLD-ARITH, SLD-READ, and AVE-ACH

Dependent Variable	Discriminant Standardized Beta Weights
Visual-Matching	.5881
Spatial-Relations	.5742
Analysis-Synthesis	.5810
Concept Formation	-.4493
Benton Copying	-.05
Benton Discrepancy	.19

Significance of canonical variate, chi square = 62.71 P=.0001.
Note. All groups N=30.

Table 7
Discriminant Analysis
Step 4 SLD-ARITH, SLD-READ, and AVE-ACH

Variable Name	Step Entered	F to Remove
Visual-Matching	1	7.30
Spatial-Relations	2	5.27
Analysis-Synthesis	3	6.27
Concept Formation	4	3.44

Significance of canonical variates $F=8.94$ $P < .01$.
Note. All groups N=30.

Table 8
Classification Matrix
All 3 Groups

Group	Percent Correct Classification	Number of cases classified into each group		
		SLD-ARITH	SLD-READ	AVE-ACH
SLD-ARITH	66.7	20	8	2
SLD-READ	53.3	7	16	7
AVE-ACH	83.3	2	3	25
Total	67.8			

Table 9
Correlations

	IQ	Visual-Matching	Spatial-Relations	Analysis-Synthesis	Concept Formation	Benton Copying	Benton Discrepancy
IQ							
Visual-Matching	.52						
Spatial-Relations	.51	.54					
Analysis-Synthesis	.48	.46	.39				
Concept Formation	.51	.40	.40	.58			
Benton Copying	.27	.16	.25	.34	.31		
Benton Discrepancy	-.11	-.16	-.28	-.26	-.13	.13	

Note. N=90.

Table 10
MANOVA with IQ Covariate

Dependent Variable	Univariate F Value	Discriminant Standardized Beta Weights
Visual-Matching	10.97***	.5679
Spatial-Relations	7.99***	.5542
Analysis-Synthesis	6.49**	.6512
Concept Formation	.13	-.5751
Benton Copying	.18	-.0594
Benton Discrepancy	.12	.1742

*P < .05.
**P < .01.
***P < .001.

Multivariate overall F=3.81 P < .0001.
Significance of canonical variate, chi square = 41.58 P < .0001.

Note. All groups N=30.
All dependent variables degrees of freedom = 2/87.

Table 11
Univariate F Values
For 6 Dependent Variables
Comparing SLD-ARITH = SLD-READ

Dependent Variable	Mean Square	Univariate F
Visual-Matching	38.40	5.92**
Spatial-Relations	209.06	5.37**
Analysis-Synthesis	163.35	10.26***
Concept Formation	4.81	.12
Benton Copying	.06	.04
Benton Discrepancy	9.6	2.56

Multivariate overall F = 3.42 $\underline{P} < .01$.
*$\underline{P} < .05$.
**$\underline{P} < .01$.
***$\underline{P} < .001$.

Note. All groups N=30.
All dependent variables, degrees of freedom = 1/58.

Table 12
Weights for All
Six Dependent Variables
in Discriminating SLD-ARITH and SLD-READ

Dependent Variable	Discriminant Standardized Beta Weight
Visual-Matching	.3665
Spatial-Relations	.4430
Analysis-Synthesis	.9343
Concept Formation	-.6933
Benton Copying	-.1430
Benton Discrepancy	-.0216

Significance of canonical variate, chi square = 18.76 $\underline{P} < .01$.
Note. All groups N = 30.

Table 13
Discriminant Analysis
Step 2 SLD-ARITH and SLD-READ

Variable Name	Step Entered	F to Remove
Analysis-Synthesis	1	9.05
Visual-Matching	2	4.84

Approximate overall F = 8.52 $\underline{P} < .001$.
*$\underline{P} < .05$.
**$\underline{P} < .01$.
***$\underline{P} < .001$.

Table 14
Classification Matrix
SLD-ARITH, SLD-READ

Group	Percent Correct Classification	Number of cases classified into each group	
		SLD-ARITH	SLD-READ
SLD-ARITH	70.0	21	9
SLD-READ	73.3	8	22

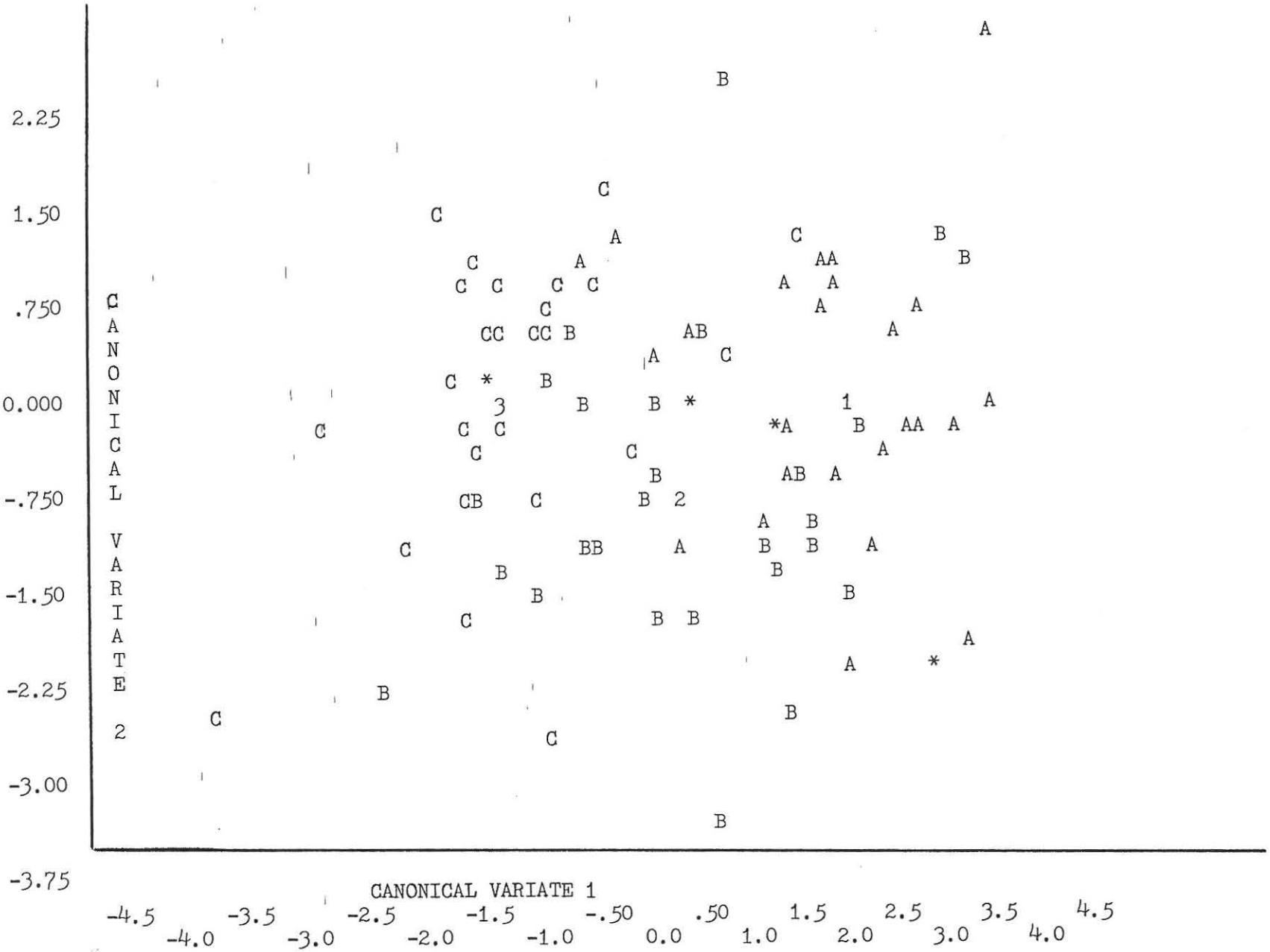

Figure 1. Plot of Canonical Variates 1 and 2. Mean centroids are indicated by *.