Reading Disability and Mathematics Disability: Is There a Correlation?

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As the former Supervisor of Mathematics, Science, and Gifted Education for Bedford County Public Schools and as the current Principal of Staunton River Middle School, I have been interested in research related to mathematics disability and how to provide the most beneficial remedial services to students who exhibit mathematics difficulties. As the annual measurable objective (AMO) for mathematics performance has continued to climb to its current rate of 90% based on federal and state mandates, it has inevitably become harder and harder to achieve adequate yearly progress (AYP). Within the category of mathematics performance, schools must meet the current AMO for the 2011-2012 school year in overall student performance as well as in the six subcategories of black students, economically disadvantaged students, Hispanic students, limited English proficient students, students with disabilities, and white students. Currently, many schools provide remediation services as a way to assist students with the skills they need for a better mathematical foundation and to ultimately enhance their subsequent performance on summative assessments. The remediation opportunities are provided to struggling mathematics students based on mathematics strand performance information obtained from various formative assessment and previous years summative assessments correlated to Virginia Mathematics Standards of Learning (SOLs) with no regards to reading ability or disability.

My review was conducted in order to provide me with research-based findings that could assist me in developing a better means of providing remediation to students who exhibit mathematics difficulties (Evans, 2008). In my review of articles, there were three specific student disability groups that were identified and referenced throughout the research: students exhibiting mathematics and concurring reading disabilities (MD-RD students), students exhibiting reading disabilities but not exhibiting mathematics disabilities (RD-only students), and students

exhibiting mathematics disabilities but not exhibiting reading disabilities (MD-only students) (Bryant, 2005; Bryant & Bryant, 2008; Evans, 2008; Fuchs, Fuchs, & Prentice, 2004; Knopik, Alarcón, & DeFries, 1997; Powell, Fuchs, Fuchs, Cirino, & Fletcher, 2009; Wise et al., 2008). These groups were identified based on specific skill strengths or deficiencies that were evident as these students completed reading and mathematics assessments. Article reviews will follow that summarize specific findings that were noted in the literature. The paper concludes with implications for leadership based on the overall findings.

Research Summaries

Knopik, V.S., Alarcón, M., & DeFries, J.C. (1997). Comorbidity of mathematics and reading deficits: Evidence for a genetic etiology. *Behavior Genetics, 27*(5), 447-453.

Content

This study involved reviewing sets of twins and their performance on specific tests, to determine the potential genetic effect and/or heritable nature of reading and math disabilities. Knopik et al. (1997) cited research from DeFries et al. (1997) when they stated that "the primary objective of this study [was] to assess the genetic etiology of the comorbidity of mathematics and reading deficits by analyzing data from two twin samples tested at the Colorado Learning Disabilities Research Center" (pg. 448). Considerable research was referenced regarding the perceived heritable component of phonological awareness. Under the premise that MD-RD disabilities are similar to RD-only disabilities with regards to phonological awareness (PA), Knopik et al. (1997) set out to correlate the heritable influence of MD using studies of twins: fraternal and identical.

Research Methodology

In this study, 244 sets of twins selected from 27 school districts in Colorado were studied. Within the 244 sets of twins, there were 100 sets of same-sex fraternal twins and 144 sets of identical twins. Parental release was obtained to review school testing records for the sets of twins. All twin pairs where at least one twin was identified as having a reading and/or mathematics disability were invited to complete a battery of tests. The twins were placed into sample groups based on their identification as RD-only, MD-only, or MD-RD using the results from the testing data. A multiple regression model was used to analyze the data obtained from the twin testing to determine if there was a genetic component linked to the identified disabilities (Knopik et al., 1997).

Analysis

Evidence from review of the data indicated that approximately 50% of the reading deficits seen in the twin sampling were due to heritable influences. A slightly smaller percentage was seen with regards to the mathematics deficits seen in the sampling of the twins. One concern for me was the fact that the MD-only and MD-RD groups were considerably smaller than the RD-only group. I would like to see further research using twins with larger sample sizes. With that said, one of the characteristics that made this study so unique was the fact that the study used twins.

Wise, J., Pae, H., Wolfe, C., Sevcik, R., Morris, R., Lovett, M., et al (2008). Phonological awareness and rapid naming skills of children with reading disabilities and children with reading disabilities who are at risk for mathematics difficulties. ***Learning Disabilities Research & Practice, 23*****(3), 125-136.**

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Wise et al. (2008) cited previous research regarding the similarities in difficulties observed between MD-RD students and RD-only students. They went on to develop research questions that would guide their study. Wise et al. (2008) identified their study questions as follows:

(1) How was phonological awareness (PA) and rapid automatized naming (RAN) related to children's mathematics achievement?

(2) How did these abilities impact mathematics performance, as compared to reading, by children with RD and [MD-RD]?

(3) Does using a more stringent criterion for classification of [MD] result in differential relations between PA and RAN skills and reading and mathematics achievement?

(4) Does classifying children with [MD] using a different cutoff criterion influence interpretations concerning the relationship between RD and [MD-RD] groups? (pg. 127)

Wise et al. (2008) cited research conducted by Fletcher (2005) when they stated that there are those who believe that MD-only disability and MD-RD disability are two completely different disabilities: one being a true mathematics disability and the latter being more of a language-based disability similar to the disability experienced by RD-only students. The resulting information from this study did not support findings reported in other research that students with RD-only and students with MD-RD have similar deficiencies with regards to PA skills.

However, it should be noted that that the study did show that PA skills are a good predictor of math achievement while RAN skills were identified as a better gauge of reading achievement.

Research Methodology

Participants in this study were second and third-grade public school students in Atlanta, Boston, and Toronto who were referred to the project by their supervising teachers based on exhibited skill deficiencies. Of the 114 students participating, 75 were considered RD-only students, while the other 39 participants were considered MD-RD based on their concurring deficiencies in the areas of mathematics and reading. Forty-seven of the selected participants were female while 59 were Caucasian. All participants were given assessment/tasks to measure phonological awareness, intelligence quotient (IQ), random automatized naming (RAN) speed, reading performance (subtests for word identification, word attack, and passage comprehension), and mathematics performance (subtests for numeration, Geometry, addition, subtraction, measurement, time, and money) at the start of the school year. Wise et al. (2008), wrote that:

> Doctoral-level graduate students and psychologists administered all measures in a one-on-one setting within the child's typical school day. All doctoral students received several hours of training in test administration and were monitored by experienced psychologists before data analysis was carried out independently. (pg. 128)

Multivariate Analysis of Variance (MANOVA) techniques were used to assess group performance of various skills related to PA, RAN, reading achievement, and math achievement. Afterwards, hierarchical regression analyses were conducted on the various student groups identified as RD-only and MD-RD. This allowed for similarities and

differences in reading and mathematics skills to be noted. There was no student group identified as MD-only for comparison in this study.

Analysis

MANOVA techniques were appropriately selected for use in this study since there were multiple dependent variables being considered. There was evidence that PA issues did correlate to mathematical difficulties on assessments that were given. Most of the studies that I reviewed contained RD-only, MD-only, and MD-RD groups for comparison. This study, however, did not include a MD-only group for reference and/or comparison. Since other research indicates that children identified as MD-only and MD-RD have different math disabilities, it would be beneficial to use a MD-only group for comparison that should not exhibit PA similarities with the RD-only group.

Fuchs, L.S., Fuchs, D., & Prentice, D. (2004). Responsiveness to mathematical problem-solving instruction: Comparing students at risk of mathematics disability with and without risk of reading disability. *Journal of Learning Disabilities, 37*(4), 293-306. doi:177/00222194040370040201

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Fuchs et al. (2004) used testing measures to determine if disability was evident in the participating students. Students were therefore placed into four subgroups: RD-only, MD-only, RD-MD, and ND (not exhibiting reading or mathematics disability). Group designations were determined as follows: MD-RD (< 25 the percentile on the Reading Comprehension and Computation subtests), RD-only (< 25^{th} percentile on the Reading Comprehension subtest and > 40^{th} percentile on the Computation subtest), MD-only (25^{th} percentile on the Computation

subtest and > 40th percentile on the Reading Comprehension subtest), and ND (> 40th percentile on the Reading Comprehension and Computation subtests). According to Fuchs et al. (2004), the study was designed to address the following question: "Does third-grade students' responsiveness to generally effective classroom instruction on math problem solving vary as a function of disability…and performance dimension" (pg. 295). The baseline treatment consisted of teachers following county curriculum with specific emphasis on certain problem types correlated to the study. Experimental treatments included lessons taught on the following topics: basic math, problem solving, shopping list, half, buying bags, and pictographs. All lessons were scripted for review by instructors but were not required to be read. Students with disabilities improved less than their nondisabled counterparts, who were identified as ND, as a function of treatment. This research sets the stage for further research regarding differentiated instruction being applied to a child's specific disability/deficiency.

Research Methodology

Three hundred and one third-grade students from 24 classrooms in six schools in a southeastern school district were the participants in this study. The students were supervised by 24 participating teachers. By randomly assigning teachers to conditions being reviewed (8 control, 8 transfer, and 8 transfer plus self-regulation), stratification was achieved with each condition represented equally in each participating school. With this said, 16 of the 24 classrooms actually participated in the study. The 301 students were present for pre- and posttesting measures. Pretesting and posttesting occurred within three weeks prior to and following the treatment, respectively. The measures consisted of the use of spring *TerraNova* state assessment scores with 25th percentile cutoff being used to identify disability. Specific focus was given to the Computation and Reading Comprehension subtests. Data were collected

in class settings by trained research assistants. A three-factor analysis of variance (ANOVA) was conducted.

Analysis

I feel it was appropriate to use a three-factor ANOVA as the measures of understanding, computation, and labeling were being compared across all four disability type subgroups (MD-only, RD-only, MD-RD, and ND). Disability type, treatment, and time (pre- and posttest) were the three variables that were used for cross-group comparison. The data showed that students in the MD-RD group showed the weakest performances of all students participating in the study across all three measures. As expected, the ND students exhibited the highest levels of performance across all three measures, the MD-only students outperformed their RD-only counterparts in the areas of understanding and labeling, and the RD-only students outperformed their MD-only counterparts in the area of computation.

Evans, M. Underlying cognitive processes in reading, math, and comorbid reading and math learning disabilities. Ph.D. dissertation, University of Waterloo (Canada), Canada. Retrieved April 2, 2012, from Dissertations & Theses: Full Text. (Publication No. AAT NR43269).

Content

In this study, "the cognitive profiles of children with average overall IQ and ND, single RD or MD, and comorbid RD+MD [were] investigated to further understand the unique and possibly shared cognitive deficits in single and comorbid disability groups" (Evans, 2008, pgs.1-2). Based on the results of the cognitive testing, it was hoped that the information gleaned would allow a better understanding of what leads to various math and reading achievement levels. Two major foci of the study were: 1) determining the specific cognitive processing deficits affecting

reading and mathematics disabilities, respectively, and 2) determining which cognitive processing deficits, if any, were seen in students who were identified as having both reading and mathematics deficiencies (pg. 2).

Research Methodology

Participants in this study were 4th grade students form three separate school districts. The 240 students were chosen based on average range percentile scores (25th – 74th) on multiple tests including, but not limited to, the Wechsler Abbreviated Scale of Intelligence (WASI) and the Woodcock-Johnson Tests of Achievement, Third Edition, Form B (WJ-III). According to Evans (2008), "an ANOVA was run to assess for significant differences between and within groups on each variable" (pg. 40). Specifically, three contrasts were considered during the study. Evans (2008) listed them as:

1) No disability (ND) compared to all three disability groups (reading (RD), math (MD), and reading/math (RD+MD))
2) RD+MD group compared to the two single disability groups (RD and MD)
3) RD group compared to the MD group. (pg. 40)

Regression analyses were then run in hopes that results would enhance "our understanding of what factors/cognitive processes (strong or weak) contribute to good or poor reading and math achievement" (Evans, 2008, pg. iii).

Analysis

Once again, I feel the selection of ANOVA was appropriate due to the fact that multiple measures were being compared across all disability type subgroups: RD-only, MD-only, MD-RD, and ND. According to Evans (2008), a better understanding of reading and mathematics achievement was seen based on a review of student profiles. Evans (2008) elaborated further to

state that "this profiling could be of value to psychologists when evaluating single versus comorbid reading and math disabilities" (pg. 135). As always, the goal of such a project is to obtain information that will prove to be beneficial to students as we work to understand why some students struggle with material in certain core fields of study.

Powell, S., Fuchs, L., Fuchs, D., Cirino, P., & Fletcher, J. (2009). Effects of fact retrieval tutoring on third-grade students with math difficulties with and without reading difficulties. *Learning Disabilities Research & Practice, 24*(1), 1-11. doi:10/1111/j1540-5826.2008.01272.x

Content

This randomized control study was aimed at determining whether a student's math fact retrieval ability was linked to their specific type of math disability, MD-only or MD-RD, and to see how these students responded to different fact retrieval tutoring conditions. After students had been identified as to which math disability type they possessed, they were randomly assigned into one of four intensive tutoring groups: control (no tutoring), fact retrieval practice, conceptual instruction with fact retrieval practice, and procedural computation/estimation instruction. Some of the tutoring sessions were geared to enhance fact retrieval capabilities while others were not. Powell et al. (2009) wrote:

> We found that MD-only students in the two fact retrieval tutoring conditions outperformed the MD-only students in the two contrast groups that did not receive fact retrieval tutoring…By contrast; MD-RD students who received either version

> of fact retrieval tutoring did not improve significantly better than MD-RD students in either of the contrast conditions. (pgs. 8-9)

Research Methodology

At the beginning of the study, over 1100 students from 32 third-grade classrooms and 43 third-grade classrooms were administered the Wide Range Achievement Test 3 (WRAT) Arithmetic in a large group format. The group was narrowed to a group of 175 students that were randomly assigned into one of four study group conditions. All tutoring sessions, excluding the control group, consisted of one-on-one tutoring, 15-25 minutes three times per week for 15 weeks (Powell et al., 2009). By the end of the intervention, Powell et al. stated that 139 students remained of the original 175 that started. Statistical and graphical analyses were done using pretest and posttest data for the two MD subgroups: MD-only and MD-RD.

Personal Analysis

The participants in the math subgroups in this study, MD-only and MD-RD, were provided with consistently administered tutoring sessions. Based on my review of articles, this was unique as there was other research where poor instruction was listed as a confounding variable. Since instruction was consistent across all groups, the differences seen in the MD subgroups could be attributed to the differences in the disabilities seen between these groups rather than differences in instruction. Based on the findings from this study, MD-only students responded better to fact-retrieval tutoring than did their MD-RD counterparts.

Findings

Although there is a relatively vast amount of research available on reading disabilities, the quantity of current research on mathematics disabilities pales in comparison (Bryant, 2005; Bryant & Bryant, 2008; Fuchs, Fuchs, & Prentice, 2004; Knopik, Alarcón, & DeFries, 1997; Wise et al., 2008). This is an interesting finding as mathematics disabilities are thought to be

manifested in 4% to 8% of all school-age children, a significantly noted prevalence even when compared to the identified reading disabilities found in 17% to 20% of the same population (Bryant, 2005; Evans, 2005; Fuchs, Fuchs, & Prentice, 2004; Wise et al., 2008).

According to Powell et al. (2009), students identified as MD-RD struggle with mathematics because of specific deficits in phonological processing skills which limit their acquisition of vocabulary and math facts. Correlations between PA at school entry ages and arithmetic performance at later ages were noted by Bryant et al. (1990) who referenced specific identified deficient PA skills. When thinking about the difficulties of students recognized as MD-only, weak number sense skills tend to be prevalent, often exhibiting in poor recall of math facts (Powell et al., 2009). When viewing the collective research, patterns appear which relate the disabilities of MD-RD students to those language based difficulties of RD-only students with the only noticeable difference being the deficiency level of their phonological processing skills (Fuchs, Fuchs, & Prentice, 2004; Wise et al., 2008). As such, MD-RD can be considered "a language-based learning disability that shares a common etiology with RD rather than a disability with mathematics skills" (Wise et al., 2008, pg. 126). Looking at math disability, specifically subgroups within the comprehensive category, is a relatively new area of study since most research on learning disabilities has focused on the area of reading (Bryant, 2005; Bryant & Bryant, 2008; Fuchs, Fuchs, & Prentice, 2004; Knopik, Alarcón, & DeFries, 1997; Wise et al., 2008). Knowing that the two MD subgroup types are characterized by different deficiencies will allow for a variety of strategies to be used to help these students overcome their deficits.

Based on the findings of the articles reviewed, there is promise that additional studies will provide even more information that will facilitate a better understanding of math disabilities and those who exhibit them. This is essential in today's era of accountability, when attention is

finally being given to mathematics performance by individuals at the local, state, and national levels (Bryant, 2005). Understanding that members of the student population learning the general education curriculum, as well as members of the student populations learning modified curricula, can exhibit various types and levels of math disability will be critical as the work to assist these students continues.

Leadership Implications

The findings of these studies would seem to indicate that students with math difficulties who have been identified into the two disability subgroups of MD-only and MD-RD should be remediated using different strategies. School leaders can use this information to help identify remediation groups, no longer based on missed question strand information, but rather on the skills that could be affecting the student's ability to grasp the mathematics concepts. This correlates to the conclusions of Wise et al. (2008) who wrote: "…those individuals within the school setting that are responsible for assessment and educational placement need to account for potential group classification differences and issues related to the stringency of the criteria used for placement" (pg. 134). If there is one or more math remediation group within a school, then there are probably MD-only and MD-RD students within each group.

As educational leaders, we must use available data, if they exist, to identify the math disability subgroups within our math remediation groups. If the data are not available, it would be worthwhile to be able to gather the necessary data to make subgroup identifications possible. These types of data are quite often readily available in elementary settings and could easily be used to coordinate remedial group placements. Since the data imply that MD-RD students have similar difficulties as RD-only students, it would be appropriate to work with these students to improve their PA skills as a way of helping them with their mathematics disabilities. MD-only students on the other hand, traditionally tend to have deficiencies in number sense skills and

therefore would benefit from remedial opportunities that can enhance their specific skills. If we do not use available data to place students into appropriate subgroups by math disability type, then our hopes of providing students with the best strategies and opportunities are diminished.

Based on this review of research, it would seem logical to try to replicate the findings to confirm the similarities and difference between RD-only, MD-only, and MD-RD disabilities. According to Evans (2008), "future investigations may be able to customize remedial programs that target the specific cognitive deficits of single and comorbid reading and math disabilities, and allow for better evidence-based monitoring of the impact of such programs on reading and math acquisition in atypical learners" (pg. 137). Many School Improvement Plans (SIPs) reflect increases in math performance as one of their goals. This information is critical is helping to ensure increases in mathematics performance. As a building principal, this is very beneficial information that can be used to help guide decision-making processes to structure the remedial programs in a building around specific deficits and deficiencies to better meet the students' academic needs.

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