ENCYCLOPEDIA on Early Childhood Development

Learning disabilities

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Synthesis

How important is it?

Learning disabilities are problems that affect the child's ability to receive, process, analyze or store information. They can make it difficult for this child to read, write, spell or solve math problems.

Dyscalculia, or mathematical disability, refers to a persistent difficulty in learning or understanding number concepts, counting principles or arithmetic. These difficulties are often called a mathematical disability. Between 3% and 8% of school-aged children show persistent grade-to-grade difficulties in learning such mathematical concepts.About half of children with dyscalculia are also delayed in learning to read or have a reading disability, and many have attention deficit disorder (ADD).

Dyslexia, or reading disability, refers to an unexpected difficulty in reading, "unexpected" meaning that all the factors necessary for reading appear to be present (intelligence, motivation and at least adequate reading instruction), yet the child is still struggling to read. Reading difficulties are not only highly prevalent (estimates range from 25% to 40%); they are also persistent. Roughly 75% of children who struggle to read in third grade will continue to struggle throughout school.

Failure in reading is highly correlated with overall school failure and subsequent behaviour, social and emotional problems, with reading considered a protective factor that helps to counter social and/or economic disadvantage. Mathematics competence accounts for variance in employment, income and work productivity. Learning disabilities are therefore a serious public-health problem, leading to life-long difficulties in learning skills both in school and in the workplace, and creating financial burdens on society.

What do we know?

Dyscalculia

Many studies indicate that dyscalculia is not related to intelligence, motivation or other factors that might influence learning. Most of the children affected have specific deficits in one or more areas, but often perform at grade level or better in other areas.

The early signs of dyscalculia include a poor understanding of number magnitude, a rigid understanding of counting, and use of immature strategies during problem-solving. In first grade, children with dyscalculia often do not know basic number names (e.g. “9” = “nine”), and have difficulty identifying which number is larger or smaller.

Almost all children – including those with dyscalculia – are able to learn the basic counting sequence (“one, two, three, four…”). However, some children have difficulty with the rules that underlie the ability to count effectively. These include *one-one correspondence* (one and only one word tag, e.g. “one,” “two,” is assigned to each object), *stable order* (the order of the word tag is the same across counted sets), and *cardinality* (the value of the final word tag represents the quantity of items in the set).

Many children with dyscalculia have trouble remembering basic arithmetic facts, such as the answer to 5+3.Many of these children use immature problem-solving strategies, such as relying on finger counting for more years than other children, and they make more mistakes when counting.

Anxiety about mathematics can lead to errors. Dyscalculia is very likely to eventually result in frustration and avoidance, and potentially excess anxiety that, in addition to the underlying cognitive deficit, will almost certainly make it more difficult to learn mathematics.

Dyslexia

The key discovery related to dyslexia is that reading is not natural, but is acquired and must be taught. To read, a child must learn how to connect the abstract lines and circles (i.e. letters) on a page to the sound of spoken language.

Recent evidence suggests both genetic and environmental influences in the development of dyslexia. A child with an affected parent is 80 times more likely to be dyslexic. Boys and girls who come from disadvantaged backgrounds are especially at risk for developing reading difficulties, because they tend to have less exposure to language and often lack the vocabulary skills or background knowledge necessary to develop strong reading comprehension skills.

Although multiple developmental paths lead to dyslexia, children in need of preventive training can be identified early by using two sources of information: the family background in relation to reading, and the development of skills that can predict reading acquisition (e.g. letter knowledge).

Learning disabilities, if left untreated, compromise knowledge acquisition, expose a child to repeated experiences of failure and may reduce motivation for learning in general. For dyslexia as well as dyscalculia, providing early help may avoid many of the associated problems that affect self-esteem and emotional well-being.

What can be done?

Dyscalculia

In the primary grades, number combinations and word problems are two key concepts for establishing a strong foundation. *Number combinations* are one-digit addition and subtraction problems (e.g. 3+2=5). As the learner becomes proficient in counting strategies, these pairs and associations move to long-term memory. *Word problems* are linguistically presented questions that require sorting through information and adding or subtracting one- or two-digit numerals.

To improve number combination skills, there are two intervention approaches: conceptual instruction, where the teacher structures experiences to foster interconnected knowledge about quantities and guides students to correct understandings; and drill and practice, where repeated pairings of problem stems with correct answers serve to establish representations in long-term memory. The latest research reports that a combination of these approaches results in better outcomes.

To enhance word problem skills, two additional approaches exist: metacognitive instruction, in which teachers help students apply planning and organizational strategies, and schema-based instruction, in which students first master rules for solving problem types and then develop schemas to group problems into types that require similar solution strategies.

There is still much to be done in terms of basic research, assessment and remediation of mathematical disabilities. A standardized diagnostic test is needed to obtain more precise information on such aspects as counting knowledge and mathematical problem-solving procedures for elementary school children with dyscalculia. Measures are also needed to identify preschoolers at risk. As well, more research is required on basic counting and arithmetic skills in preschool children as they relate to later risk of dyscalculia, the genetics of dyscalculia and the neurological systems that might be involved, and the co-occurrence of reading and math problems.

Finally, the anxiety and avoidance of mathematics that are likely to result from the cognitive deficits must be addressed. Without attention to the frustration and anxiety, a risk for exacerbated and long-term problems in math exists.

Dyslexia

Brain imaging studies have revealed differences in brain activation patterns between good and poor readers. When poor readers were taught with evidence-based methods, however, their neural systems reorganized to resemble the brain activation patterns of those observed in children who were good readers. This demonstrates that teaching really matters.

In 2000, the National Reading Panel appointed by the U.S. Congress reported that to learn to read, children must be taught five elements of reading: phonemic awareness, phonics, fluency, vocabulary and reading comprehension. *Phonemic awareness* is the ability to notice and identify the individual sounds of spoken words (e.g. “mat” has three phenomes: “mmm”-“aaa”-“t”). *Phonics* is the ability to link letters to individual sounds. The knowledge that these two components are key to developing a foundation for reading means that such skills and awareness can be taught to young children, even before they are expected to read.

Simple rhyming games help children as young as three years old begin to appreciate that spoken words come apart. For example, to know that “mat,” “hat” and “cat” rhyme, a child must be able to focus on only a part of the word (the rhyme “at”). Gradually, children learn to pull words apart, push them together and move the parts around. Simple activities such as clapping to the number of sounds (syllables) in a spoken word help children learn how to pull apart words.

Training and strengthening the core reading processes is the most likely way to boost reading skills. Any activity that helps to develop language skills is to be welcomed, but from age five, there should be more systematic practice of at least five to 20 minutes per day, realized in the context of play. The most appropriate preventive procedure is to use a consistency principle that favours the most dominant and frequent letter-sound connections.

Children who are at risk should be identified and helped as early as possible. Language development should be assessed beginning at age two – especially for children from families with a background of dyslexia. If no delay is observed, the next stage of identification of potential risk is at age four, when spontaneous acquisition of letter knowledge provides good evidence of the possible need for preventive practice.

Ultimately, young children’s literacy development involves a dynamic thinking and linguistic process, incorporating problem-solving, discussion, reflection and decision-making. Effective interventions for children who may be at risk of developing learning disabilities should therefore focus on multidimensional learning.

Resolving questions about optimum approaches in the teaching of literacy and mathematics for children at risk is more than an academic question, but has ramifications at the national and international levels. Providing young children with these basic skills enhances their academic, emotional and social well-being, with lifelong implications.

Dyscalculia at an Early Age

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Introduction

Dyscalculia refers to a persistent difficulty in learning and understanding mathematics. For children, these difficulties are manifested as a slow learning of number concepts and basic arithmetic. During the preschool years, the core difficulty that may presage risk for long-term math difficulties is delayed learning of the magnitudes associated with number words and Arabic numerals (i.e., learning their cardinal values), and in the early elementary school years, a poor understanding of the relations among numbers (e.g., 17 = 10 and 7) and difficulties committing basic arithmetic facts to long-term memory.[1] These early delays put children behind in learning other areas of mathematics on which this basic knowledge is foundational, and make it difficult for them to catch up to their peers. Fortunately, researchers are beginning to develop and test interventions to prevent or ameliorate these early deficits.[2,3]

Subject: How Common is Dyscalculia?

Between 3 and 8% of school-aged children show persistent and severe grade-to-grade difficulties in learning some aspects of number and arithmetic, or in mathematics generally.[4,5] These and other studies indicate that these learning disabilities, or dyscalculia, are not strongly related to intelligence or motivation, but many of these children having difficulty keeping one thing in mind while doing something else, that is, they have working memory deficits.

The finding that 3 to 8% of children have dyscalculia is misleading in some respects. On the one hand, the cutoffs are artificial because mathematical competence varies on a continuum, and children identified as dyscalculic are simply at the lower end of the continuum; the diagnostic cutoffs could be moved higher or lower. On the other hand, many of these children have specific deficits in one or a few math areas (e.g., remembering basic arithmetic facts), but often perform at grade level or better in other areas (e.g., conceptually understanding numbers). About half of these children are also delayed in learning to read or have a reading disability, and many have attention deficit disorder.[6]

Problems: What are the Common Features of Dyscalculia?

During the preschool years, children at risk for later problems in mathematics have a delayed understanding of the meaning of number words and Arabic numerals.

In the elementary school years, many children with dyscalculia have difficulties committing basic facts to long-term memory. They may learn and remember that '5 x 2 is 10' one day, but forget this the next day or retrieve a related but wrong answer from memory (e.g., '7', confusing '5 + 2' with '5 x 2').

Research Context and Recent Research Results

Number

As noted, preschool children who are slow at learning the meaning of number words and Arabic numerals (e.g., that 'four' and '4' represent a collection of four things) are at higher risk than other children for poor long-term mathematics achievement. The understanding of the meaning of number words and numerals is foundational to later mathematics learning and thus these early delays may cascade into broader delays in understand the relations among numbers, such as 25 is composed of 2 tens and 5 ones. This delayed understanding in turn can influence their learning of arithmetic.[7]

Arithmetic

The basic arithmetic skills of children with dyscalculia have been extensively studied.[8,9] These studies, which have focused on how children solve simple arithmetic problems (e.g., 4 + 5 =?), such as finger counting or remembering the answer, have revealed several very consistent patterns:

First, many children with dyscalculia have difficulties remembering basic arithmetic facts, such as the answers to 5+3.[1] It is not that these children do not remember any arithmetic facts, but rather that they cannot remember as many facts as other children do and appear to forget facts rather quickly. Second, many of these children use immature problem-solving strategies. For example, they rely on finger counting to solve arithmetic problems for more years than other children, and they make more mistakes when counting. Many of these children catch up with respect to problem-solving strategies but remembering facts is a more persistent issue.[8]

Key Research Questions: Socio-Emotional Development

This is an area in which there is very little research. However, we now understand that anxiety about mathematics can lead to errors, because thoughts about how well you are doing can intrude into consciousness and disrupt the working memory resources needed for mathematical problem-solving.[10] Although math anxiety does not typically emerge until after delays in number understanding are apparent, dyscalculia is very likely to eventually result in frustration, avoidance and potentially excess anxiety when having to solve math problems. Any such anxiety will be in addition to the underlying cognitive deficits and will almost certainly make the learning of mathematics even more difficult.

Conclusions

Between 3 and 8% of school-aged children will show evidence of dyscalculia. The early signs of this form of disability include a poor understanding of number magnitude (e.g., that 8 < 9), and use of immature strategies during the solving of arithmetic problems. One of the most common and long-term problems is difficulty remembering basic arithmetic facts (e.g., 4+2 = “6”). These children are likely to be at risk for development of math anxiety, which will lead to avoidance of mathematics and make the acquisition of basic skills in this area even more difficult.

Implications: Where Do We Go from Here?

There is much that needs to be done is this area in terms of basic research, assessment and diagnosis, and, of course, remediation, but at the same time important advances have been made in recent years.

Basic Research

Recent advances include a better understanding of the early quantitative abilities that set the foundation for learning mathematics in school. At this time, it appears that the key for 3- to -4 year olds is learning the standard counting sequence (one, two, three…) and basic numerals (1, 2, 3…) and more importantly coming to understand the cardinal values they represent (e.g., that ‘3’ and ‘three’ represent any three things). By the time they enter first grade, children need to have a firm understanding of numbers and the relations between them (e.g., that 6 = 5+1, 4+2, 3+3…). Children who are delayed in number learning and basic arithmetic are at heightened risk of falling behind their peers in mathematics learning and staying behind throughout schooling.

Even with these advances, we need to learn more about the genetics of dyscalculia and the neurological and the very early cognitive knowledge that might be involved in delays in number and arithmetic learning. We need to know more about the co-occurrence of reading and math problems, and how these problems may relate to risk of math anxiety and school avoidance.

Diagnosis and Remediation

Generally, children who score below the 25th percentile on standardized mathematics achievement tests for two or more consecutive years are at risk for poor long-term mathematics achievement, even if they do not have the underlying cognitive deficits (e.g., poor memory for basic facts) that contribute to dyscalculia; poor instruction or motivation may contribute to the below average performance of many of these children. Children who consistently (across grades) score below the 10th percentile (about 3 to 8% of children) are very likely to have dyscalculia. These children do learn number and arithmetic, as well as other aspects of mathematics, but they tend to remain behind their peers.

Lynn Fuchs at Vanderbilt University and Vinod Menon at Stanford University School of Medicine are working on the development of interventions for these children, and trying to better understand the brain systems that contribute to their delayed mathematical learning.[2,3]

Socio-Emotional Functioning

In addition to remediation for the cognitive deficits associated with dyscalculia, the anxiety and avoidance of mathematics that is likely to result from these deficits needs to be addressed.10 Without attention to the frustration and anxiety that is likely to be associated with dyscalculia, a risk for exacerbated and long-term problems in math exists.

References

1. Geary DC. Mathematics and learning disabilities. *Journal of Learning Disabilities* 2004;37(1):4-15.
2. Fuchs LS, Geary DC, Compton DL, Fuchs D, Schatschneider C, Hamlett CL, Deselms J, Seethaler PM, Wilson J, Craddock CF, Bryant JD, Luther K, Changas P. Effects of first-grade number knowledge tutoring with contrasting forms of practice. *Journal of Educational Psychology* 2013; 105, 58-77.
3. Jolles D, Supekar K, Richardson J, Tenison C, Ashkenazi S, Rosenberg-Lee M, Fuchs L, Menon V. Reconfiguration of parietal circuits with cognitive tutoring in elementary school children. *Cortex* 2016;83:231-45.
4. Badian NA. Dyscalculia and nonverbal disorders of learning. In: Myklebust HR, ed. *Progress in learning disabilities Vol 5*. New York, NY: Grune & Stratton; 1983:235-264.
5. Kosc L. Developmental dyscalculia. *Journal of Learning Disabilities* 1974;7(3):164-177.

6. Shalev RS, Manor O, Gross-Tsur V. The acquisition of arithmetic in normal children: Assessment by a cognitive model of dyscalculia. *Developmental Medicine and Child Neurology* 1993;35(7):593-601.
7. Geary DC, vanMarle K. Young children's core symbolic and non-symbolic quantitative knowledge in the prediction of later mathematics achievement. *Developmental Psychology* 2016; 52, 2130-2144.
8. Geary DC, Hoard MK, Nugent L, Bailey DH. Mathematical cognition deficits in children with learning disabilities and persistent low achievement: A five year prospective study. *Journal of Educational Psychology* 2014; 104, 206–223.
9. Jordan NC, Hanich LB, Kaplan D. Arithmetic fact mastery in young children: A longitudinal investigation. *Journal of Experimental Child Psychology* 2003;85(2):103-119.
10. Moore AM, McAuley AJ, Allred GA, Ashcraft MH. Mathematics anxiety, working memory, and mathematical performance. In Chinn S, ed. *The Routledge International Handbook of Dyscalculia and Mathematical Learning Difficulties*. NY Routledge; 2014: 326-336.

Dyslexia at an Early Age and Its Impact on Early Socio-Emotional Development

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Introduction

Developmental dyslexia was first reported in 1896, by a British physician, W. Pringle Morgan, who described Percy F., a young student who was bright in every way, except for his inability to read.[1] Today, over a century later, we continue to see bright children who struggle to read. Dyslexia refers to an unexpected difficulty in reading; “unexpected” meaning the child appears to have present all the factors necessary for reading (intelligence, motivation and at least adequate reading instruction), and yet is still struggling to read.[2] Although referred to as an “invisible” disability, dyslexia has profound effects on a child, both through the impact of the effort reading requires and through the great cost in terms of shame and anxiety associated with not being able to read quickly or smoothly.

Subject

The key discovery related to reading is that reading is not natural, but is acquired and must be taught. Although reading has its roots in spoken language, there are profound differences between reading and speaking. Spoken language is natural; expose an infant to a speaking environment and that child will learn to speak on his/her own. Reading is acquired and must be taught. To read, a child must learn how to connect the abstract lines and circles (letters) on a page to the sounds of spoken language. This process has two components. First, the child must develop an awareness that spoken words are comprised of elemental particles called phonemes; for example, the spoken word “mat” has three underlying phonemes (“mmmm”-“aaaa”-“t”). This ability to notice and identify the individual sounds of spoken words is called *phonemic awareness.* Next, the child learns how to link letters to these individual sounds, a process called *phonics*. This process begins with a child learning the names and shapes of the individual letters, recognizing them and then learning how to print the letters. As the letters are mastered, the child begins to learn how letters represent speech sounds and then how to use this knowledge to decode or sound out individual words. Much of this activity involving speech sounds and letters begins in the preschool period, when a solid foundation for reading is developed.

Simple rhyming games help children as young as three years old begin to appreciate that spoken words come apart; to know that mat, hat and cat rhyme, a child must be able to focus on only a part (the rhyme) - the “at” in this series of words. Progressively, preschool children go on to compare sounds in different words and then learn to “work on words,” pulling them apart (segmenting), pushing them together (blending), and moving the parts within a word around.[3] Simple activities such as clapping to the number of sounds (syllables) in a spoken word help children learn how to pull apart words. Currently, there are several commercial programs that help to teach these early skills to young children.[4]

Problems

Reading difficulties are not only highly prevalent (estimates range from 25% to 40%);[5-7] they are also persistent.[3,8-9] This is in contrast to the widely held, but incorrect, notion that reading problems in young children represent a developmental lag that will be outgrown. Knowledge that early reading problems persist adds a sense of urgency to providing young children with effective reading instruction. Seventy-five percent of children who struggle to read in third grade will continue to struggle throughout school.[3,7]

Research Context

A range of studies, both in the laboratory and in the classroom, have examined the ”what” and the “how” of teaching reading, that is, the influence of providing instruction in the specific components of the reading process and how they are most effectively taught. In particular, these studies have served to address questions related to two competing hypotheses of teaching children to read. The first hypothesis posits that children best learn to read naturally by learning to construct meaning from print,[10] and the components of reading are learned implicitly. The second suggests that the major components of the reading process need to be taught by methods that are explicit and provide systematic instruction about how letters relate to sounds.

Key Research Questions

Reflecting the prevalence and persistence of reading problems, the critical question is: what are the most effective methods and approaches for providing reading instruction to young children to help them become skilled readers?

Recent Research Results

In 1998, the U.S. Congress, concerned about the high prevalence of reading difficulties, mandated that a National Reading Panel be appointed and review the existing reading research literature to determine the most effective methods to teach reading to young children. Two years later, the Panel reported its findings.[11] To learn to read, children must be taught five elements of reading: 1) phonemic awareness; 2) phonics; 3) fluency (the ability to read not only accurately, but rapidly and with good understanding); 4) vocabulary; and 5) reading comprehension. The Panel reported on the most effective methods for teaching each of these components; furthermore, the evidence indicated that children learn best when they are taught explicitly in an organized, systematic fashion. The findings of the Panel represent a landmark in the development of "evidence-based education," where instruction is based on rigorous research findings rather than anecdotal information or philosophical leanings. Intervention studies have confirmed the significant impact of such instruction.[12,13] With the advent of new brain imaging techniques, we can now appreciate the impact of instruction from a neurobiological perspective. Such brain imaging studies have revealed differences in brain activation patterns between good and poor readers; good readers activate three systems on the left side of the brain, while struggling readers show diminished activation in two of these areas located in the back of the left side of the brain.[14,15] Importantly, these imaging studies demonstrate that when young children are taught with such "evidence-based" methods, the neural systems within their brains are able to take advantage of the instruction, reorganizing to resemble the brain activation patterns observed in children who are good readers.[16] This study demonstrated beyond a doubt that teaching matters. Recent evidence suggests both genetic[17] and environmental influences in the development of dyslexia.

Conclusions

Dyslexia is both highly prevalent and persistent. As children mature, they increasingly depend on print to gain knowledge. While beginning readers learn more from what they hear than from what they see, by seventh grade the balance tips to favour reading so that by college, most of students' knowledge and vocabulary are gained from reading.[18] Children learn about 3,000 new words a year; this means that a dyslexic child who is not identified and taught by effective methods until third grade is already close to 10,000 words behind his peers,[19,20] and must not only catch up, but keep up as well. Converging evidence indicates that reading is acquired and the critical difficulty reflects a problem in phonological processing.[21] A new evidence-based approach to teaching children to read is now emerging; behavioural as well as neurobiological studies indicate the effectiveness of such approaches, particularly in the early school years. Studies indicate that reading difficulties are multifactorial, influenced by both inherent (genetic) and experiential factors. By providing help early, many of the associated problems that affect self-esteem and emotional well-being may be avoided.

Implications

The findings that reading problems persist and that evidence-based approaches are effective in remediating these difficulties in young children have significant implications for policies affecting the education of young children. In addition, the knowledge that the ability to notice and manipulate the sounds of spoken language as well as letter knowledge are key to developing a foundation for reading means that such skills and awareness can be taught to young children, even before they are expected to read. And there is now accumulating evidence that these early reading skills can be taught to young children in ways that are both enjoyable and effective. Children who enter formal schooling prepared to learn to read are at a distinct advantage over those who do not possess these skills. Boys and girls who come from disadvantaged backgrounds with less exposure to language often do not have the vocabulary skills or background knowledge necessary to develop strong reading comprehension skills and are especially at risk for developing reading difficulties. Such children benefit from very early exposure to vocabulary development and to learning about the world around them. How this is best accomplished remains an open question. What is not open to question is that preparing young children to become readers has salutary effects on their socio-emotional development as well as their schooling.

References

1. Morgan WP. A case of congenital word blindness. *British Medical Journal* 1896;1871:1378-1379.
2. Shaywitz SE. Dyslexia. *Scientific American* 1996;275(5):98-104.
3. Shaywitz S. *Overcoming dyslexia: A new and complete science-based program for reading problems at any level*. New York, NY: Alfred A. Knopf; 2003.
4. Wendon L. *Letterland*. Enfield, NH: Letterland International Ltd.; 1992.
5. Snow CE, Burns MS, Griffin P, eds. *Preventing reading difficulties in young children*. Washington, DC: National Academy Press; 1998. Available at: http://books.nap.edu/books/030906418X/html/index.html. Accessed January 30, 2006.
6. Perie M, Grigg W, Donahue P. *The nation's report card: Reading 2005*. Washington, DC: U.S. Department of Education, National Center for Education Statistics, U.S. Government printing Office; 2005. NCES 2006-451. Available at: http://nces.ed.gov/nationsreportcard/pdf/main2005/2006451.pdf. Accessed January 30, 2006.

7. Shaywitz SE, Shaywitz BA. Unlocking learning disabilities: The neurobiological basis. In: Cramer SC, Ellis W, eds. *Learning disabilities: lifelong issues*. Baltimore, Md: Paul H. Brookes Pub.; 1996:255-260.

8. Francis DJ, Shaywitz SE, Stuebing KK, Shaywitz BA, Fletcher JM. Developmental lag versus deficit models of reading disability: A longitudinal, individual growth curves analysis. *Journal of Educational Psychology* 1996;88(1):3-17.

9. Shaywitz BA, Holford TR, Holahan JM, Fletcher JM, Stuebing KK, Francis DJ, Shaywitz SE. A Matthew effect for IQ but not for reading: Results from a longitudinal study. *Reading Research Quarterly* 1995;30(4):894-906.

10. Birsh JR. *Multisensory teaching of basic language skills*. 2nd ed. Baltimore, Md: Paul H. Brookes Pub.; 2005.

11. National Reading Panel. *Teaching children to read: An evidence-based assessment of the scientific research literature on reading and its implications for reading instruction*. Washington, DC: U.S. Department of Health and Human Services, National Institute of Child Health and Human Development; 2000. Pub. No. 00-4754. Available at: http://www.nichd.nih.gov/publications/nrp/upload/smallbook_pdf.pdf. Accessed November 2nd, 2007.

12. Torgesen JK. The prevention of reading difficulties. *Journal of School Psychology* 2002;40(1):7-26.

13. Lovett MW, Lacerenza L, Borden SL, Frijters JC, Steinbach KA, DePalma M. Components of effective remediation for developmental reading disabilitites: Combining phonological and strategy-based instruction to improve outcomes. *Journal of Educational Psychology* 2000;92(2):263-283.

14. McCandliss BD, Cohen L, Dehaene S. The visual word form area: expertise for reading in the fusiform gyrus. *Trends in Cognitive Sciences* 2003;7(7):293-299.

15. Shaywitz BA, Shaywitz SE, Pugh KR, Mencl WE, Fulbright RK, Skudlarski P, Constable RT, Marchione KE, Fletcher JM, Lyon GR, Gore JC. Disruption of posterior brain systems for reading in children with developmental dyslexia. *Biological Psychiatry* 2002;52(2):101-110.

16. Shaywitz BA, Shaywitz SE, Blachman BA, Pugh KR, Fulbright RK, Skudlarski P, Mencl WE, Constable RT, Holahan JM, Marchione KE, Fletcher JM, Lyon GR, Gore JC. Development of left occipitotemporal systems for skilled reading in children after a phonologically-based intervention. *Biological Psychiatry* 2004;55(9):926-933.

17. Meng HY, Smith SD, Hager K, Held M, Liu J, Olson RK, Pennington BF, Defries JC, Gelernter J, O'Reilly-Pol T, Somlo S, Skudlarski P, Shaywitz SE, Shaywitz BA, Marchione K, Wang Y, Paramasivam M, Lo-Turco JJ, Page GP, Gruen JR. DCDC2 is associated with reading disability and modulates neuronal development in the brain. *Proceedings of the National Academy of Sciences of the United States of America* 2005;102(47):17053-17058.

18. Sticht T, Beck L, Hauke R, Kleiman G, James J. *Auding and reading: a developmental model*. Alexandria, Va: Human Resources Research Organization; 1974.

19. Just MA, Carpenter PA. *The psychology of reading and language comprehension*. Boston, Mass: Allyn and Bacon; 1987.

20. Nagy WE, Herman PA. Breadth and depth of vocabulary knowledge: Implications for acquisition and instruction. In: McKeown MG, Curtis ME, eds. *The nature of vocabulary acquisition*. Hillsdale, NJ: Lawrence Erlbaum Associates; 1987:19-35.

21. Morris RD, Stuebing KK, Fletcher JM, Shaywitz SE, Lyon GR, Shankweiler DP, Katz L, Francis DJ, Shaywitz BA. Subtypes of reading disability: Variability around a phonological core. *Journal of Educational Psychology* 1998;90(3):347-373.

Early Identification of Language Delay

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Introduction

Because language is central to so many aspects of human life – cognition, social interaction, education and vocation – valid identification, prevention, and treatment of language disorders is a high priority for the therapeutic professions. Delay and/or difficulty in beginning to use language is one of the most common causes of parental concern for young children brought to pediatricians and other professionals. Delay may indicate specific difficulty with language, or it may be an early indicator of a broader problem such as developmental delay or autism.

Subject

In this article, we summarize current knowledge about the assessment of young children's language below age 3, particularly in the range of 24 to 30 months (for which we have the most extensive information), in order to identify early language delay and/or risk for persistent language impairment. The goal of this screening process is to guide decisions concerning the need for further evaluation and treatment, in order to prevent the development of more significant problems. Language sampling and analysis have substantial time and expertise requirements.

Problems

Early identification of language delay must resolve two fundamental problems. The first is the problem of obtaining valid information at an age when children are often not sufficiently compliant for direct testing, especially those with limited communication skills who are the primary focus. Furthermore, the assessment technique must be cost-effective with respect to professional time, and broadly applicable across a range of social classes and language backgrounds, including bilingualism. Language sampling and analysis have substantial time and expertise requirements.

The second problem is one of interpretation. Many children whose language is delayed at 24 or 30 months will catch up over the next few years, and do not warrant intervention.[1] The challenge is to identify and use other relevant information to improve decisions about individual children.

Research Context

The solution to the first problem above has been the revival of an older, but neglected technique: parent report.[2,3] Parents have much more experience with their children than professionals, and their experience is more representative of their child's experiences and interests. Vocabulary checklists and related questions for parents have proven to be highly valid measures of early language development.[4,5,6,7,8,9,10]

Solving the second problem has required two programs of research: first, large-scale norming studies to provide a basis for judgment of the relative status of a child's language (delayed or not) [3] and second, longitudinal studies of outcome of early delay to identify predictors of "spontaneous recovery" or continued delay.[1]

Key Research Questions

Five questions are central to early identification of language delay:

1. What is a valid criterion for defining early language delay?
2. How much variability in outcome is there for early delay?
3. What other factors can add to prediction of outcome, and how should they be integrated?
4. How do differences related to social class, gender, and ethnicity affect the identification process?
5. How should the process be modified for children acquiring two or more languages?

Recent Research Results

Toddlers who have not attained the expressive language skills exhibited by most children the same age can be identified as having slow expressive language development (SELD). Among English-speaking children, studies suggest that 90% of 24-month-olds have an expressive vocabulary of at least 40-50 words and about 85% are combining words.[6] Based on these findings, two criteria for identifying SELD among 24-month-olds are commonly used: 1) small expressive vocabulary (less than 40-50 words, or below the 10th percentile, depending on the tool used) and/or 2) no word combinations.[6,8] The 10th percentile criterion can be extended to other ages.

Children with SELD at age 2 are at 2 to 5 times higher risk for language impairment persisting into the late preschool to elementary school years than children without SELD.[1,11] Even though at least half of the two-year-olds with SELD will have language skills that are within the normal range by school age,[9,10] early expressive language delays should not be ignored, given the elevated risk of persisting language impairment.

Longitudinal studies of two-year-olds with SELD have examined a variety of potential predictor variables for persisting difficulties. Those variables which most regularly are found to make some prediction include parent concern about possible problems with the child's speech/language development or hearing, family history of language impairment or dyslexia (especially first degree relatives: parents, full siblings), receptive language delays, frequent ear infections, limited vocalizations, and delayed pretend play.[12,13,14] Although none of these is a highly accurate predictor by itself, parental concern has been the most consistently associated with language impairment.[1,10] Combining predictors has improved accuracy of predictions, but the optimal combination of predictors is not yet known.

For monolingual children who speak languages other than English, there are adaptations of the widely used *MacArthur-Bates Communicative Development Inventories* (*CDI)*[a] and the *Language Development Survey (LDS)*[8,16,17] in a number of languages. There is considerable consistency across languages in children's early expressive language development. For example, word combinations are reported for about 85% of Spanish-speaking and over 90% of French-speaking 24 to 26-month-olds children.[15,18]

Bilingual children's development of expressive vocabulary is comparable to monolingual children when parent reports for both languages are obtained and combined. There are two methods for combining vocabulary scores: "Total conceptual vocabulary (TCV)," in which words with similar meanings (e.g., English "cat" and Spanish "gato") are counted only once,[19] and "Total vocabulary (TV)" which includes all words in each language, regardless of possible overlap in meaning. For young children, TV (Language A + Language B) is recommended because it is simple to calculate and it yields vocabulary size scores and growth rates for young bilingual children that are similar to those for monolingual children's vocabulary.[20] Age of onset of word combinations also is similar for bilingual and monolingual children if bilingual children are credited with combining words if they do so in either language.[16,21,22,23]

Although pairs of monolingual forms can be used, there are also some bilingual adaptations of vocabulary checklists available, including Spanish-English[22] and German-English[16] adaptations of the *Language Development Survey* and a bilingual Spanish-English scoring adaptation of the *CDI*.[21]

Research Gaps

Variation in findings across social groups and gender differences indicates that parent report tools and/or criteria for early identification may need adjustment for different populations. The rate of identification of SELD using parent report tools is much higher for children from lower SES families; cut-offs that yield about 10% of middle class children identify two to three times as many children from lower SES backgrounds.[24] Although children from low SES backgrounds are at somewhat higher risk for language impairment, these major differences in rate of identification raise concerns about over-identifying SELD among children from lower SES backgrounds. Children from minority ethnic backgrounds had lower average scores when SES was controlled for in one study, raising similar questions about the validity of parent report tools in culturally diverse populations.[24] Finally, when uniform expressive vocabulary and word combination criteria are used, more 2-year-old boys are identified with SELD,[1,11,25] raising a question of whether different criteria may be appropriate for boys and girls. Research comparing outcomes for boys and girls with SELD is needed to address this question.

Conclusions

Young children with expressive language skills that are approximately below the 10th percentile are at much higher risk than peers for persisting language or even broader developmental problems, even though there is a wide range of outcomes and many children with SELD at two years of age are in the average range by four years of age. A variety of additional variables are associated with persisting delays, and parental concern about possible speech-language problems is a key predictor of risk for language impairment.

Implications

Early childhood educators, health care providers and other professionals can identify risk for language impairment in young children based on parent-reported information. Immediate referral to a speech-language pathologist is recommended for children with slow expressive language development if the parents are concerned that the child has possible speech-language problems or when there are additional risk factors. On the other hand, if the parents are *not* concerned about the child's speech-language development and there are no additional risk factors, monitoring ("watchful waiting") is recommended for children who are not combining words or who have a small expressive vocabulary (under 40 words) at 24 months.

Monolingual children who speak languages other than English should be referred for evaluation if they are delayed in expressive vocabulary and onset of word combinations in their native language. Because expressive language development is comparable among monolingual and bilingual children when bilingual children's development in both languages is taken into account, bilingual two-year-olds who are not combining and/or have small total expressive vocabularies should be monitored and/or referred for further evaluation.

Collaborative efforts between practitioners and researchers on large scale screening programs that combine screenings with follow-up evaluations are needed to refine and validate models for predicting persisting language impairment for children with parent-reported SELD, using other information about the child and family. These efforts should also include work to adapt, implement and validate measures for children from homes in which languages other than English are spoken, and for children from lower socioeconomic backgrounds.

References

1. Dale PS, Price TS, Bishop DVM, Plomin R. Outcomes of early language delay: I. Predicting persistent and transient language difficulties at 3 and 4 years. *Journal of Speech, Language, and Hearing Research* 2003;46(3):544-560.
2. Dale PS. Parent report assessment of language and communication. In: Cole KN, Dale PS, Thal DJ, eds. *Assessment of communication and language*. Baltimore, MD: P.H. Brookes;1996:161-182.
3. Fenson L, Dale PS, Reznick JS, Bates E, Thal DJ, Pethick SJ, eds. Variability in early communicative development. *Monographs of the Society for Research in Child Development* 1994;59(5):1-173. Theme issue.
4. Dale PS. The validity of a parent report measure of vocabulary and syntax at 24 months. *Journal of Speech and Hearing Research* 1991;34(3):565-571.
5. Dale PS, Bates E, Reznick JS, Morisset C. The validity of a parent report instrument of child language at twenty months. *Journal of Child Language* 1989;16(2):239-249.
6. Fenson L, Marchman VA, Thal DJ, Dale PS, Reznick JS, Bates E. *MacArthur-Bates Communicative Development Inventories: User's guide and technical manual*. 2nd Ed. Baltimore, Md.:Paul H. Brookes Pub. Co;2007.
7. Feldman HM, Dale PS, Campbell TF, Colborn DK, Kurs-Lasky M, Rockette HE, Paradise JC. Concurrent and predictive validity of parent reports of child language at ages 2 and 3 years. *Child Development* 2005;76(4):856-868.
8. Rescorla L. The language development survey: A screening tool for delayed language in toddlers. *Journal of Speech and Hearing Disorders* 1989;54(4):587-599.

9. Guiberson, M., Rodriguez, B. L., & Dale, P. S. Classification accuracy of brief parental report measures of language development in Spanish-speaking toddlers. *Language, Speech, and Hearing Services in Schools* 2011;42, 536-549.
10. Klee T, Pearce K, Carson DK. Improving the positive predictive value of screening for developmental language disorder. *Journal of Speech, Language, and Hearing Research* 2000;43(4):821-833.
11. Rice ML, Taylor CL, Zubrick SP. Language outcomes of 7-year-old children with or without a history of late language emergence at 24 months. *Journal of Speech, Language, and Hearing Research* 2008;51(2):394-407.
12. Ellis E, Thal D. Early language delay and risk for language impairment. *Perspectives on Language Learning and Education* 2008;15(3):93-100.
13. Olswang L, Rodríguez B, Timler G. Recommending intervention for toddlers with specific language learning difficulties: We may not have all the answers, but we know a lot. *American Journal of Speech-Language Pathology* 1998;7:23-32.
14. Lyytinen P, Eklund K, Lyytinen H. Language development and literacy skills in late-talking toddlers with and without familial risk for dyslexia. *Annals of Dyslexia* 2005;55(2):166-192.
15. Jackson-Maldonado D, Bates E, Thal D. *MacArthur Inventarios del Desarrollo de Habilidades Comunicativas: User's guide and technical manual*. Baltimore, MD: P.H. Brookes;2003.
16. Junker D, Stockman I. Expressive vocabulary of German-English bilingual toddlers. *American Journal of Speech-Language Pathology* 2002;11(4):381-394.
17. Papaeliou, C. & Rescorla, L. Vocabulary development in Greek children: A cross-linguistic comparison using the Language Development Survey. *Journal of Child Language* 2011;38, 861-877.
18. Trudeau, N. & Sutton, A. Expressive vocabulary and early grammar of 16- to 30-month-old children acquiring Quebec French. *First Language* 2011;31, 480-507.
19. Pearson B, Fernández S, Oller K. Lexical development in bilingual infants and toddlers: Comparison to monolingual norms. *Language Learning* 1993;43(1):93-120.
20. Core, C., Hoff, E., Rumiche, R., & Señor, M. Total and conceptual vocabulary in Spanish-English bilinguals from 22 to 30 months: Implications for assessment. *Journal of Speech, Language, and Hearing Research* 2013;56, 1637-1649.
21. Marchman V, Martínez-Sussman C. Concurrent validity of caregiver/parent report measures of language for children who are learning both English and Spanish. *Journal of Speech, Language, and Hearing Research* 2002;45(5):283-997.
22. Patterson JL. Expressive vocabulary development and word combinations of Spanish-English bilingual toddlers. *American Journal of Speech-Language Pathology* 1998;7:46-56.
23. Hoff, E., Core, C., Place, S., Rumiche, R., Señor, M., & Parra, M. Dual language exposure and early bilingual development. *Journal of Child Language* 2012;39, 1-27.
24. Rescorla L, Achenbach T. Use of the Language Development Survey (LDS) in a national probability sample of children 18 to 35 months old. *Journal of Speech, Language, and Hearing Research* 2002;45(4):733-743.
25. Rescorla L, Alley A. Validation of the Language Development Survey (LDS): A parent report tool for identifying language delay in toddlers. *Journal of Speech, Language, and Hearing Research* 2001;44(2):434-444.

Note:

[a] See also the MacArthur-Bates Communicative Development Inventories website. Available at: http://mb-cdi.stanford.edu/. Accessed February 15, 2017.

Strategies to Enhance Young Children's Mathematical Development

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Introduction and Subject

Evidence[1] suggests that 4 to 7% of the school-age population suffers from mathematics disability (MD). Although this prevalence rate is similar to the rate for reading disability, much less systematic study has been directed at MD.[2] Most available research describes the nature of the disorder; less work is available to inform the nature of effective prevention or remediation strategies. This relative neglect is problematic because MD is a serious public-health problem, leading to life-long difficulties in school and in the workplace and creating financial burdens on society. Mathematics competence, for example, accounts for variance in employment, income and work productivity even after intelligence and reading have been explained.[3]

Research Context

In the primary grades (e.g. kindergarten through third grade), number combinations and word problems are two key dimensions of performance required to establish a strong foundation. Not surprisingly, therefore, these two aspects of math skills are persistent and severe and can cause difficulty for students with MD.[4] *Number combinations* are addition and subtraction problems with one-digit operands (e.g. 3+2=5). Competent performance involves automatic retrieval of answers from long-term memory. Individuals develop representations in long-term memory by pairing problems with answers using increasingly sophisticated counting and back-up strategies. *Word problems* are linguistically presented questions, sometimes including irrelevant information or charts/figures, for which answers require adding or subtracting of one- or two-digit numerals. Word problems also present persistent challenges for students with MD.

Key Research Questions

A key research question concerns what intervention strategies can be used to prevent difficulty or remediate deficits that develop in the primary grades.

Recent Research Results

To answer *number combination problems* (e.g. 2+3), typical children gradually develop procedural efficiency in counting. First, they count the two sets in their entirety (1, 2, 3, 4, 5); then they count from the first number (2, 3, 4, 5); and eventually they count from the larger number (3, 4, 5). As conceptual knowledge matures, children also develop backup strategies (2+3=[2+2]+1=4+1=5). As increasingly efficient counting and backup strategies help children consistently and quickly pair problems with correct answers, associations become established in long-term memory, and children gradually favour memory-based retrieval of answers.

Students with MD, however, manifest greater difficulty with counting5 and persist with immature backup strategies. So it is not surprising that they also fail to make the shift to memory-based retrieval of answers.6 When MD children do retrieve answers from memory, they commit more errors and manifest unsystematic retrieval speeds more than younger, academically normal counterparts.7 In fact, number combination deficits are a signature characteristic of students with MD. Prior work suggests the challenge of remediating this deficit with intermediate-grade students,8,9 which is unfortunate because number combination skill (NCS) appears to be foundational to higher-order performance.4 Given the foundational role NCS may play in the development of other math skills, along with the difficulties of remediation at higher grades, intervention may be important in the primary grades, when MD emerges.

Two competing approaches to intervention exist. With *conceptual instruction*, the teacher structures experiences to foster interconnected knowledge about quantities, with teacher explanations to guide students to correct understandings.10,11 The assumption is that NCS evolves from strong concepts, which lend meaning to the strings of numerals constituting arithmetic facts.12,13,14,15 The second intervention approach is *drill and practice*, whereby repeated pairings of problem stems with correct answers establish representations in long- term memory. Siegler’s distribution of associations model16,17 accounts for the potential importance of both approaches. The model poses that early counting skills and backup strategies provide the basis for response accuracy. All results for a given problem constitute an individual’s associations for that problem; so early errors interfere with the retrieval of number combinations later on. This suggests the need for better strategic thinking in the early stages (promoted by conceptual instruction) and the need for routine pairing of correct answers with problem stems (enhanced via drill and practice).

Unfortunately, there have been few investigations of intervention efficacy to develop NCS with children as early as in first, second or third grade. Most efficacy work is remedial, conducted with intermediate-age students, focuses exclusively on drill/practice and provides mixed results. 18,19,20 One of the few early intervention studies21 was a small pilot in first grade to assess the efficacy of computerized drill/practice. At-risk students (n = 33) were randomly assigned to analogous drill and practice conditions in math or reading, stratifying by classroom (so that students in the same classrooms were in both conditions). The reading intervention served as the control for the math intervention. Students completed 50 to 54 sessions over 14 weeks and were pre- and post-tested. The math group improved significantly more than the reading group (ES = 0.92). In an ongoing remedial study with older students,22 drill and practice software was integrated with conceptual instruction. Using a multi-site randomized controlled field trial, 128 remedial students have so far completed intervention, and results reliably favour the experimental over the control group (ES = 0.73).

With respect to enhancing *word problem skill* (WPS), most research has assessed the value of planning and organization strategies with middle- and secondary-school students. For example, Montague and Bos23 assessed the effects of an eight-step metacognitive treatment with six adolescents with learning disabilities. Students were taught to read problems, paraphrase the problems aloud, graphically display known and unknown information, state the known and unknown information, hypothesize solution methods, estimate answers, calculate answers and check answers. Using a single-subject design, the researchers showed that this metacognitive treatment promoted WPS. With group design, Charles and Lester24 provided support for a similar approach among typically developing fifth and seventh graders.

The major contrasting intervention approach for developing WPS is schema-based instruction. According to Cooper and Sweller,25 students develop WPS by first mastering rules for solving problem types and then developing schemas to group problems into types that require similar solution strategies. The broader the schema, the greater the probability individuals will recognize connections between problems they have worked during instruction and novel problems. In experimental work at the intermediate grades, Jitendra et al.26 invoked schema-based instruction to enhance WPS with good success. We have extended that work to third grade, where the goal was to promote complex WPS. For each of four problem types, students were taught problem-solution rules. Then, with schema-based instruction, children were familiarized with the notion of transfer and taught to build schemas by showing them how superficial problem features change without altering problem-solution rules. In a series of randomized controlled trials, Fuchs et al. 27,28,29 provided empirical support for this approach, with large effect sizes (0.89- 2.14). More recently, Fuchs et al.30 extended this research program at third grade to address one-step change, equalize and compare word problems. Students with math and reading disability (*n*=40) were randomly assigned to schema-based instruction and control groups; results showed the efficacy of this approach with effect sizes of 0.77 to 1.25.

Conclusions

A theoretically supported approach, for which promising empirical evidence exists for promoting NCS, is conceptually-oriented instruction into which drill and practice on number combinations is integrated. For promoting WPS, the two major competing approaches are metacognitive instruction, with which teachers help students apply planning and organization strategies, and schema-based instruction. To date, however, few investigations of intervention efficacy have contrasted the two prominent approaches for promoting NCS or WPS, and inadequate work has been conducted at the primary grades. In addition, no studies of long-term maintenance have been conducted.

Implications

MD is a serious public-health problem, leading to life-long difficulties in school and in the workplace and creating financial burdens on society. In light of the serious negative outcomes associated with poor math performance, additional research is warranted to examine methods for prevention and remediation, especially in the primary grades. At present, research tentatively supports the use of conceptually-oriented instruction into which drill and practice on number combinations is integrated for addressing number combination difficulties. Metacognitive instruction and schema-based instruction represent promising strategies for promoting word problem skills.

References

1. Gross-Tsur V, Manor O, Shalev RS. Developmental dyscalculia: Prevalence and demographic features. *Developmental Medicine and Child Neurology* 1996;38(1):25-33.
2. Rasanen P, Ahonen T. Arithmetic disabilities with and without reading difficulties: A comparison of arithmetic errors. *Developmental Neuropsychology* 1995;11(3):275-295.

3. Rivera-Batiz FL. Quantitative literacy and the likelihood of employment among young adults in the United State. *Journal of Human Resources* 1992;27(2):313-328.
4. Fuchs LS, Fuchs D, Compton DL, Powell SR, Seethaler PM, Capizzi AM, Schatschneider C, Fletcher JM. The cognitive correlates of third-grade skill in arithmetic, algorithmic computation, and arithmetic word problems. *Journal of Educational Psychology*. In press.
5. Geary DC. A componential analysis of an early learning deficit in mathematics. *Journal of Experimental Child Psychology* 1990;49(3):363-383.
6. Goldman SR, Pellegrino JW, Mertz DL. Extended practice of basic addition facts: Strategy changes in learning-disabled students. *Cognition and Instruction* 1988;5(3):223-265.
7. Geary DC, Brown SC. Cognitive addition: Strategy choice and speed-of-processing differences in gifted, normal, and mathematically disabled children. *Developmental Psychology* 1991;27(3):398-406.
8. Hasselbring TS, Goin LI, Bransford JD. Developing math automaticity in learning handicapped children: The role of computerized drill and practice. *Focus on Exceptional Children* 1988;20(6):1-7.
9. Pellegrino JW, Goldman SR. Information processing and elementary mathematics. *Journal of Learning Disabilities* 1987;20(1):23-32, 57.
10. Fuchs LS, Fuchs D, Karns K. Enhancing kindergarteners' mathematical development: Effects of peer-assisted learning strategies. *Elementary School Journal* 2001;101(5):495-510.
11. Fuchs LS, Fuchs D, Yazdian L, Powell SR. Enhancing first-grade children's mathematical development with peer-assisted learning strategies. *School Psychology Review* 2002;31(4):569-583.
12. Domahs F, Delazer M. Some assumptions and facts about arithmetic facts. *Psychology Science* 2005;47(1):96-111.
13. Landerl K, Bevan A, Butterworth B. Developmental dyscalculia and basic numerical capacities: A study of 8-9-year-old students. *Cognition* 2004;93(2):99-125.
14. Lemaire P, Siegler RS. Four aspects of strategic change: Contributions to children's learning of multiplication. *Journal of Experimental Psychology: General* 1995;124(1):83-97.
15. Gersten R, Jordan NC, Flojo JR. Early identification and interventions for students with mathematics disabilities. *Journal of Learning Disabilities* 2005;38(4):293-304.
16. Lemaire P, Siegler RS. Four aspects of strategic change: Contributions to children's learning of multiplication. *Journal of Experimental Psychology: General* 1995;124(1):83-97.
17. Siegler RS. Strategy choice procedures and the development of multiplication skill. *Journal of Experimental Psychology: General* 1988;117(3):258-275.
18. Christensen CA, Gerber MM. Effectiveness of computerized drill and practice games in teaching basic math facts. *Exceptionality* 1990;1(3):149-165.
19. Okolo CM. The effect of computer-assisted instruction format and initial attitude on the arithmetic facts proficiency and continuing motivation of students with learning disabilities. *Exceptionality* 1992;3(4):195-211.
20. Hasselbring TS, Goin LI, Bransford JD. Developing math automaticity in learning handicapped children: The role of computerized drill and practice. *Focus on Exceptional Children* 1988;20(6):1-7.
21. Fuchs LS, Fuchs D, Hamlett CL, Powell SR, Seethaler PM, Capizzi AM. . The effects of computer-assisted instruction on number combination skill in at-risk first graders. *Journal of Learning Disabilities*. In press.
22. Fuchs LS, Compton DL, Fuchs D, Paulsen K, Bryant JD, Hamlett CL. The prevention, identification, and cognitive determinants of math difficulty. *Journal of Educational Psychology* 2005;97(3):493-513.

23. Montague M, Bos CS. The effect of cognitive strategy training on verbal math problem solving performance of learning disabled adolescents. *Journal of Learning Disabilities* 1986;19(1):26-33.

24. Charles RI, Lester, FK Jr. An evaluation of a process-oriented instructional program in mathematical problem solving in grades 5 and 7. *Journal of Research in Mathematics Education* 1984;15(1):15-34.

25. Cooper G, Sweller J. Effects of schema acquisition and rule automation on mathematical problem-solving transfer. *Journal of Educational Psychology* 1987;79(4):347-362.

26. Jitendra AK, Griffin CC, McGoey K, Gardill MC, Bhat P, Riley T. Effects of mathematical word problem solving by students at risk or with mild disabilities. *Journal of Educational Research* 1998;91(6):345-355.

27. Fuchs LS, Fuchs D, Prentice K, Burch M, Hamlett, CL, Owen R, Schroeter, K. Enhancing third-grade students' mathematical problem solving with self-regulated learning strategies. *Journal of Educational Psychology* 2003;95(2):306-315.

28. Fuchs LS, Fuchs D, Prentice K, Burch M, Hamlett CL, Owen R, Hosp M, Jancek D. Explicitly teaching for transfer: Effects on third-grade students' mathematical problem solving. *Journal of Educational Psychology* 2003;95(2):293-305.

29. Fuchs, LS, Fuchs D, Prentice K, Hamlett CL, Finelli R, Courey SJ. Enhancing mathematical problem solving among third-grade students with schema-based instruction. *Journal of Educational Psychology* 2004;96(4):635-647.

30. Fuchs LS, Seethaler PM, Powell SR, Hamlett CL, Fuchs D. *Remediating third-grade deficits in word problem skill: A pilot*; 2005. Unpublished raw data.

Early Identification and Prevention of Reading Problems

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Introduction and Subject

If left untreated, difficulty with reading and writing compromises knowledge acquisition, exposes a child to repeated experiences of failure, and thus may reduce motivation for learning in general.[1] Such consequences can have a long-term impact on educational career, the learning of skills, and ultimately, the employment status that could otherwise be achieved.

For a substantial number of children, the acquisition of reading and spelling is a difficult challenge. The consequences and length of delay in this acquisition vary as a function of the nature of the writing system (orthography) being learned. In a highly regular orthography, such as Finnish, roughly 6% of children have difficulties with acquisition, while more than 3% have severe difficulties and may continue to read too slowly to facilitate the adequate comprehension of demanding text. Most, if not all, of these children can be observed to have a familial (genetic) background to their difficulties. By contrast, among children who acquire reading skills in less orthographically regular languages, such as English, the proportion of spontaneous learners is smaller and the number of delayed early learners is relatively larger, with more than 10% of young readers of English facing problems in achieving sufficient accuracy and fluency of reading and spelling.[2]

Children in need of preventive training can be identified early by using two sources of information: the history of parents and/or other close relatives, such as siblings, in relation to reading (familial background); and the development of those skills that can predict reading acquisition. The Finnish prospective data, on which the present report is based, reveal that even very early indices may be predictive.

Problems

Two important issues are how to identify those in need as early as possible and the actual nature of prevention.

Research Context

Only a small area of reading-related research has focused on early identification and prevention. Those studies that have provided information about early identification[3,4,5,6,7] have consistently observed a number of significant predictive indices. Information on family background is helpful.[3,8,9,10] Gilger et al.[11] have computed that a child with an affected parent has a risk of being dyslexic of up to 80 times what would be expected to occur in the general population. Another study puts the risk at four to five times higher than in a random sample.[10] In replicating and complementing earlier findings published by Scarborough,[6] the Jyväskylä Longitudinal Study of Dyslexia (JLD),[12,13] which looked at 100 children at familial risk for dyslexia (and matched non-risk controls) from birth to school age, found that 40% of children at familial risk encountered difficulties in acquiring reading skills, with 20% encountering very severe reading problems. The prevalence of difficulty in the control group in comparison to this 20% group with severe difficulties and with familial background was only 2%. Thus, the most persistent reading problems apparently occur among children with a familial background of dyslexia.

Although multiple developmental paths lead to dyslexia,[12-15] ultimately the common factor is compromised reading, expressed from the first steps of reading acquisition, such as learning of letter names. In terms of prevention and irrespective of the etiology of any difficulty associated with reading, this means that time spent in training and strengthening the core reading processes is the most likely guarantor of success in terms of elevating reading skill.

Key Research Questions

Finnish is one of the most regular writing systems: there are only 21 phonemes/letters, a letter from the Swedish alphabet (as the second official language) and 1 two-letter grapheme. Six additional phonemes occur only in loan words. With little exception therefore, each single sound in the Finnish language is consistently represented by a single letter and vice versa. With such bi-directionally consistent correspondence between the graphemes and phonemes of Finnish, the learning load is therefore minimal. Consequently, Finnish children’s reading problems tend to manifest in the storage and fluent automatic retrieval of these few letter-sound connections. This difficulty can even occur in children with average to above-average IQ and surprisingly, sometimes in children with good or precocious general language development. This poses a challenge to the early identification of children with such an explicit specific reading difficulty.

Recent Research Results

Results from the JLD have shown that speech processing and perception measures taken in infancy[16-20] and delayed expressive language and to some extent, delayed receptive language in toddlerhood, can differentiate children who end up with reading problems from those who do not, among children at familial risk for dyslexia.[21] From age three, the predictive measures include phonological skills.[22] However, the single most easy to use and reliable predictor is letter knowledge from three years of age;[23] when combined with rapid naming[24] at age five or later, low scores on both of these indices seem to lead to accurate prediction of reading failure, with only a few false positives if no preventive training is provided.

In some cases, the difficulty ican be observed solely in letter-sound learning. This finding is not surprising, as it is acknowledged that the effects of including letters in phonology training programs are additive.[25,26,27] Thus, dynamic testing of letter sounds from age four may be the most appropriate single tool for early identification, as letter sound learning difficulty seems to be a bottleneck, irrespective of the developmental path which precedes the reading failure.[28] For learners of transparent writing systems, the initial focus of this dynamic testing should involve vowel sound items (before introduction of consonants). In contrast, and in the absence of such solid consistency between sounds and letters, more complex writing systems such as English should focus on sound items that are most consistent in terms of occurrence in the language. As a consequence, no child in need would be left without preventive support if, during dynamic assessment, those children who demonstrate low scores in storing letter names, are afforded the opportunity to start learning the sounds of the written items, not later than at the time of school entry (see below).

All this provides cues to the best prevention strategies. Nevertheless, the letter-sound association learning should be organized in such a way that the child enjoys learning and continues to practice until the goal has been reached. In Finnish, this goal is simply the learning of the letter-sound connections. The case with less regular orthographies, such as English, is much more complex, and this poses a major challenge to learning the connections between written and spoken language units. Nonetheless, we believe that a preventive training procedure, using a consistency principle that favours the most dominant and frequent letter-sound connections as the initial step, is the most appropriate for preventive training of reading in alphabetic languages, irrespective of the complexity of the orthography. One such preventive tool that we have developed (GraphoGame)[29] is based on a computer game that ensures that children experience success, thus motivating them to continue for long enough to achieve the goal of learning the letter-sound relationships. This computerized intervention has demonstrated success (acceleration of letter knowledge, especially in those children with poor initial pre-reading skills) when implemented in the beginning phase of reading acquisition in Finnish.[30,31] Preliminary findings concerning English, especially in the context of GraphoGame Rime, are also promising,[32] while extension of GraphoGame to other languages, including learning English as a second language, is having a noticeable impact.[33] The criticisms of many (albeit effective) remediation programs often relate to their cost-effectiveness in terms of implementation costs and manpower requirements.[34] With its simplicity, child-friendly and child-directed interface, the GraphoGame computer game environment ensures better economy on both of these counts.

Conclusion

Children who are at high risk for difficulties in the acquisition of basic reading skill should be helped as early as possible. Those in need of preventive practice can be identified with simple methods of letter-sound acquisition, the core skill of reading. This can be practiced long before the child encounters too many experiences of failure at school: encounters that may have detrimental effects on learning motivation. Such training should, however, be highly enjoyable and, when provided in a game context, appropriate for children at this age – five to six years.

Implications

Children, especially those whose familial background points to the possibility of risk for reading failure, should be attended to from age two with regard to language development. If no delay is observed, the next stage of identification of potential risk is at age four, when spontaneous acquisition of letter knowledge provides good evidence of the possible need for preventive practice. If no or few (1 to 5) letters are familiar to the child, a short game to learn some new letter-names is instigated. If acquisition proves difficult, the child may require slowly increasing attention to reading-related learning. All activity that aids the development of language skills is to be welcomed but, from age five, more systematic practice (realized in the context of play) of at least 5 to 20 minutes' duration per day should be in place for the years (kindergarten to grade 2-3) during which the child needs help in order to match classmates' rate of learning. It is important that rudimentary skills be acquired sufficiently early to help the child glean enjoyment from reading. Beyond this, the best learning environment is, of course, reading itself, and the most challenging issue is how to sustain the child's interest in reading. The results of the JLD, as well as

U.S. data,[35] show that approximately 20% of children who have familial background and serious difficulty at the beginning of their reading acquisition become fully "compensated." The main characteristic of these individuals is a sustained interest in literacy, as documented by their long educational careers.

References

1. Chapman JW, Tunmer WE. Reading difficulties, reading-related self-perceptions, and strategies for overcoming negative self-beliefs. *Reading and Writing Quarterly* 2003;19(1):5-24.
2. Pennington BF. *Diagnosing learning disorders: A neuropsychological framework*. New York, NY: Guilford Press; 1991.
3. Elbro C, Borstrom I, Petersen DK. Predicting dyslexia from kindergarten: The importance of distinctness of phonological representations of lexical items. *Reading Research Quarterly* 1998;33(1):36-60.
4. Lyytinen H, Aro M, Eklund K, ErskineJ, Guttorm TK, Laakso M-L, Leppänen PHT, Lyytinen P, Poikkeus A-M, Richardson U, Torppa M. The development of children at familial risk for dyslexia: birth to early school age. *Annals of Dyslexia* 2004;54(2):184-220.
5. Pennington BF, Lefly DL. Early reading development in children at family risk for dyslexia. *Child Development* 2001;72(3):816-833.
6. Scarborough HS. Very early language deficits in dyslexic children. *Child Development* 1990;61(6):1728-1743.
7. Snowling MJ, Gallagher A, Frith U. Family risk of dyslexia is continuous: Individual differences in the precursors of reading skill. *Child Development* 2003;74(2):358-373.
8. Hallgren B. Specific dyslexia ("congenital word-blindness"): a clinical and genetic study. *Acta Psychiatrica et Neurologica Scandinavia* 1950;65(Suppl.):1-287.
9. Volger GP, DeFries JC, Decker SN. Family history as an indicator of risk for reading disability. *Journal of Learning Disabilities* 1984;17(10):616-618.
10. Wolff PH, Melngailis I. Familial patterns of developmental dyslexia: Clinical findings. *American Journal of Medical Genetics* 1994;54(2):122-131.
11. Gilger JW, Pennington BF, deFries JC. Risk for reading disability as a function of parental history in three family studies. *Reading and Writing: An Interdisciplinary Journal* 1991;3(3-4):205-217.
12. Torppa M, Lyytinen P, Erskine J, Eklund K, Lyytinen H. Language development, literacy skills and predictive connections to reading in Finnish children with and without familial risk for dyslexia. Journal of Learning Difficulties 2010;43(4):308-321. Open access.
13. Lyytinen H, Erskine J, Hämäläinen J, Torppa M, Ronimus M. Dyslexia – Early Identification and Prevention: Highlights from the Jyväskylä Longitudinal Study of Dyslexia. Current Developmental Disorders Reports 2015;2:330-338 . doi:10.1007/s40474-015-0067-1 Open access.
14. Lyytinen H, Ahonen T, Eklund K, Guttorm TK, Laakso M-L, Leinonen S, Leppänen PHT, Lyytinen P, Poikkeus A-M, Puolakanaho A, Richardson U, Viholainen H. Developmental pathways of children with and without familial risk for dyslexia during the first years of life. *Developmental Neuropsychology* 2001;20(2):535-554.
15. Vellutino FR, Fletcher JM, Snowling MJ, Scanlon DM. Specific reading disability (dyslexia): what have we learned in the past four decades? Journal of Child Psychology and Psychiatry 2004;45(1):2-40.
16. Guttorm TK, Leppänen PHT, Poikkeus A-M, Eklund KM, Lyytinen P, Lyytinen H. Brain event-related potentials (ERPs) measured at birth predict later language development in children with and without familial risk for dyslexia. *Cortex* 2005;41(3):291-303.

17. Lyytinen H, Guttorm TK, Huttunen T, Hämäläinen J, Leppänen PHT, Vesterinen M. Psychophysiology of developmental dyslexia: a review of findings including studies of children at risk for dyslexia. *Journal of Neurolinguistics* 2005;18(2):167-195.

18. Leppänen PHT, Hämäläinen J, Salminen HK, Eklund K, Guttorm T, Lohvansuu K, Puolakanaho A, Lyytinen H. (2010). Brain event-related potentials reveal atypical processing of sound frequency in newborns at-risk for familial dyslexia and associations to reading and related skills. Cortex 2010;46:1362-1376. doi:10.1016/j.cortex.2010.06.003

19. Guttorm T, Leppänen PHT, Hämäläinen J, Eklund K, Lyytinen H. Newborn event-related potentials predict poorer pre-reading skills in children at-risk for dyslexia. Journal of Learning Disabilities 2010; 43(5):391-401. doi:10.1177/0022219409345005

20. Hämäläinen J, Lohvansuu K, Ervast L, Leppänen PHT. Event-related potentials to tones show differences between children with multiple risk factors for dyslexia and control children before the onset of formal reading instruction. International Journal of Psychophysiology 2015;95(2):101-112. doi:10.1016/j.ijpsycho.2014.04.004 Open access.

21. Lyytinen H, Aro M, Holopainen L, Leiwo M, Lyytinen P, Tolvanen A. Children's language development and reading acquisition in a highly transparent orthography. In: Joshi RM, Aaron PG, eds. *Handbook of orthography and literacy*. Mahwah, NJ: Lawrence Erlbaum Associates; 2006:47-62.

22. Puolakanaho A, Poikkeus A-M, Ahonen T, Tolvanen A, Lyytinen H. Assessment of three-and-a-half-year-old children’s emerging phonological awareness in a computer animation context. *Journal of Learning Disabilities* 2003;36(5):416-423.

23. Lyytinen H, Ronimus M, Alanko A, Taanila M, Poikkeus A-M. Early identification and prevention of problems in reading acquisition *Nordic Psychology* 2007;59:109-126.

24. Denckla MB, Rudel RG. Rapid “automatized” naming (R.A.N.): Dyslexia differentiated from other learning disabilities. *Neuropsychologia* 1976;14(4):471-479.

25. Bus AG, van IJzendoorn MH. Phonological awareness and early reading: A meta-analysis of experimental training studies. *Journal of Educational Psychology* 1999;91(3):403-414.

26. Ehri LC, Nunes SR, Willows DM, Schuster BV, Yaghoub-Zadeh Z, Shanahan T. Phonemic awareness instruction helps children learn to read: Evidence from the National Reading Panel’s meta-analysis. *Reading Research Quarterly* 2001;36(3):250-287.

27. Hatcher PJ, Hulme C, Snowling MJ. Explicit phoneme training combined with phonic reading instruction helps young children at risk of reading failure. *Journal of Child Psychology and Psychiatry* 2004;45(2):338-358.

28. Lyytinen H, Erskine J, Tolvanen A, Torppa M, Poikkeus A-M, Lyytinen P. Trajectories of reading development: A follow-up from birth to school age of children with and without risk for dyslexia. *Merrill-Palmer Quarterly* 2006;52(3):514-546.

29. Richardson U, Lyytinen H. The GraphoGame Method: The Theoretical and Methodological Background of the Technology-Enhanced Learning Environment for Learning to Read. Human Technology: An Interdisciplinary Journal on Humans in ICT Environments 2014;10(1):39-60.

30. Hintikka S, Aro M, Lyytinen H. Outcomes of a computerized training of correspondences between phonological and orthographic units: Do children with low pre-reading skills profit? *Written Language and Literacy* 2005;8:155-178.

31. Saine NL, Lerkkanen M, Ahonen T, Tolvanen A, Lyytinen H. Computer-assisted remedial reading intervention for school beginners at risk for reading disability. *Child Development* 2011;82:1013-28.

32. Kyle F, Kujala J, Richardson U, Lyytinen H, Goswami U. Assessing the effectiveness of two theoretically motivated computer-assisted reading interventions in the United Kingdom: GG rime and GG phoneme. *Reading Research Quarterly* 2013;48(1):61-76.

33. Ojanen E, Rominus M, Ahonen T, Chansa-Kabali T, February P, Jere-Folotiya J, et al. GraphoGame – a catalyst for multi-level promotion of literacy in diverse contexts. *Frontiers in Psychology* 2015;6(671):1-13.

34. Fawcett A. Reading remediation: An evaluation of traditional phonologically based interventions. A review for the Department for Education and Skills, the British Dyslexia Association and the Dyslexia Institute; 2002.

www.teachernet.gov.uk.

35. Lefly DL, Pennington BF. Spelling errors and reading fluency in compensated adult dyslexics. *Annals of Dyslexia* 1991;41:143-162.

Early Prevention of Learning Disabilities: Comments on Lyytinen and Erskine, and Fuchs

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Introduction

The identification and prevention of learning disabilities and subsequent intervention are prime objectives for those concerned with early childhood development. It is known that untreated learning difficulties lead to high rates of mental illness;[1] social and emotional problems;[2] behaviour problems in school[3] and incarceration in our prison system.[4,5] Failure in early reading is highly correlated with overall school failure and later antisocial behaviour.[5,6] The papers presented by Lyytinen and Erskine, and Fuchs are worthy representations of current empirical research in the two very important areas of early literacy and maths development.

Research and Conclusions

In their overview of early identification and prevention of reading difficulty, Lyytinen and Erskine highlight the important issue of unresolved learning difficulties and the subsequent lack of motivation resulting from failure. Without adequate and effective treatment, only a minority of children with reading difficulties achieve satisfactory levels of reading. It is therefore imperative that we understand, design and evaluate the optimum approaches for these children.

The authors have brought to our attention the considerable difficulties associated with “irregular” versus “regular” orthographies. This is an important consideration when we attempt to compare literacy levels in different contexts. In contrast to the figures of 6% and 3% quoted in this paper, up to 15% of Australian children still fail national benchmark tests in reading, despite receiving intervention support.[7]

The point regarding the genetic influence on reading disability is timely and one that must be emphasized in current literature on effective screening measures.[8] The point is also made that children who have the most persistent reading problems are those with a familial background of dyslexia.

The two research questions posed are how to identify those in need as early as possible and the actual nature of the intervention.

While the authors acknowledge all the early indicators of reading difficulty, including receptive and expressive language and phonological skills, they seem to have concentrated on letter knowledge as the only predictor on the grounds that it is easy to use and a reliable predictor. Rapid naming is also mentioned, but it is not clear in the text whether this means rapid naming of codes (letters or numbers) or objects. Codes are better predictors and they also predict later reading comprehension rather than the acquisition of reading per se. I would argue that alphabet knowledge is influenced by “nurture” versus “nature,” and if we imply that familial influences are vital, then we should be concentrating on those skills associated with familial incidence, namely output phonology and vocabulary.[8,9]

Computer games that enhance letter-sound relationships are ideal as a form of practice and are certainly cost-effective and motivational, but children with potentially severe inherited reading difficulties will require much more explicit intervention than that proposed in this paper. Most children will require instruction in phonological awareness (awareness of the sound structure of words, e.g. rhyme) prior to receiving instruction in phonics (sound-letter relationships). This point is made in the implications section: “Children, especially those whose familial background points to the possibility of risk for reading failure, should be attended to from age two with regard to language development.” Perhaps this area should be expanded and include relevant screening measures at age two for language development? Byrne[10] makes the point that children who are slower at mastering foundation literacy knowledge and concepts are going to require more of everything – more explicit instruction, more opportunities to practice, and more general assistance: the need is for differential approaches and rate of instruction.

As with literacy, low mathematics competence is also related to lifelong difficulties in school and the workplace. Fuchs demonstrates the components of number combinations and word problems and how both of these skills may contribute to mathematics disability.

Conceptual instruction is included, as well as drill and practice, and this important concept is often neglected in the teaching of mathematics foundation skills. Fuchs also emphasizes the need for early intervention versus remedial instruction in later grades. This again alleviates all the attributes associated with failure, such as low self-esteem and related behaviour problems.

The latest research reported is very exciting in that a combination of approaches results in better outcomes, with computers used to enhance drill and practice and explicit conceptual instruction. All too often, we see computer programs being used irresponsibly, without the scaffolding required by providing explicit teaching.

The metacognitive strategies reported are also admirable, and again this is an area that should be combined with drill and practice in the teaching of mathematics. The use of planning and reflection, together with active participation in the learning process, and the explicit teaching of conceptual knowledge, benefits students in three ways: (1) in comprehension and learning of the concepts; (2) in understanding the steps involved in working out a solution; and (3) in their ability to use and generalize their knowledge to new situations.[11]

The schema-based strategies are also exciting and build on the use of metacognitive strategies. I do not see these two strategies as being mutually exclusive. Consideration has also been given to long-term maintenance, which is an area often overlooked in the area of intervention for students with learning difficulties.

Implications for Development and Policy

Resolving questions about optimum approaches in the teaching of literacy and mathematics for children at risk is more than an academic question; it has ramifications at the national and international levels, at the teacher preparation level, at the classroom and family levels, as well as enhancing the academic, emotional and social well-being of the child.

Failure in early reading is highly correlated with overall school failure and later behaviour and social and emotional difficulties, with reading considered a protective factor that helps to counter social and/or economic disadvantage.[12] Theoretical, experimental and clinical evidence points to the necessity of helping unskilled readers acquire explicit knowledge of phonological word structure,[13] and this should be part of any intervention program for struggling readers.

As for computer-assisted learning, it should be noted that young children's literacy development involves more than rote learning; it is a dynamic thinking and linguistic process, incorporating problem-solving, discussion, reflection and decision-making.[14] Practice is often seen as an end in itself, a way of ensuring that learners commit to memory a procedure or fact. If this is the case, it can undermine or sidestep any attempts that have been made at constructive, meaningful literacy learning. The student's practice has to be in a form that makes sense of the literacy task and creates fundamental ways of thinking that become the learner's own, so that the child activates that thinking to develop new ideas and carries it to real reading problems outside the classroom.

Both papers cover aspects of multi-dimensional learning, which should be the focus of effective intervention for our children who may be at risk of developing learning difficulties.

References

1. Klein JD. The National Longitudinal Study on Adolescent Health. Preliminary results: great expectations. *JAMA - Journal of the American Medical Association* 1997;278(10):864-865.
2. McCoy AR, Reynolds AJ. Grade retention and school performance: An extended investigation. *Journal of School Psychology* 1999;37(3):273-298.
3. Lerner JW. *Learning disabilities: theories, diagnosis, and teaching strategies*. 8th ed. Boston, Mass: Houghton Mifflin Company; 2000.
4. Catalano RF, Arthur MW, Hawkins JD, Berglund L, Olson JJ. Comprehensive community and school-based interventions to prevent antisocial behaviour. In: Loeber R, Farrington DP, eds. *Serious and violent juvenile offenders: Risk factors and successful interventions*. Thousand Oaks, Calif: Sage Publications; 1998:248-283.
5. Hawkins JD, Herrenkohl T, Farrington DP, Brewer D, Catalano RF, Harachi TW. A review of predictors of youth violence. In: Loeber R, Farrington DP, eds. *Serious and violent juvenile offenders: Risk factors and successful interventions*. Thousand Oaks, Calif: Sage Publications; 1998:106-146.
6. Pressley M. *Reading instruction that works: the case for balanced teaching*. New York, NY: Guilford Press; 1998.
7. Louden W, Chan L, Elkins J, Greaves D, House H, Milton M, Nichols, Rivalland J, Rohl M, van Kraayenoord C. *Mapping the territory - primary students with learning difficulties: literacy and numeracy*. Canberra City, Australia: Department of Education, Science and training, Australian Government; 2000. Available at: http://www.dest.gov.au/sectors/school_education/publications_resources/profiles/mapping_territory_primary_students_difficulties.htm# . Accessed February 7, 2006.
8. Hindson B, Byrne B, Fielding-Barnsley R, Newman C, Hine DW, Shankweiler D. Assessment and early instruction of preschool children at risk for reading disability. *Journal of Educational Psychology* 2005;97(4):687-704.
9. Heath SM, Hogben JH. Cost-effective prediction of reading difficulties. *Journal of Speech, Language, and Hearing Research* 2004;47(4):751-765.
10. Byrne B. The process of learning to read: A framework for integrating research and educational practice. In: Stainthorp R, Tomlinson P, eds. *Learning and teaching reading*. Leicester, United Kingdom: The British Psychological Society; 2002:29-44.
11. Ashman AF, Conway RNF. *An introduction to cognitive education: Theory and applications*. London, United Kingdom: Routledge; 1997.
12. Snow CE, Burns SM, Griffin P, eds. *Preventing reading difficulties in young children*. Washington, DC: National Academy Press; 1998. Available at: http://fermat.nap.edu/books/030906418X/html/index.html. Accessed February 7, 2006.
13. Blachman BA. Phonological awareness. In: Kamil ML, Mosenthal PB, Pearson PD, Barr R, eds. *Handbook of reading research*. Vol 3. Mahwah, NJ: Lawrence Erlbaum Associates; 2000:483-502.
14. Kamhi AG, Allen MM, Catts HW. The role of the speech-language pathologist in improving decoding skills. *Seminars in Speech and Language* 2001;22(3):175-183.