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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.

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