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The cognitive profile of Chinese children with mathematics difficulties

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ABSTRACT

This study examined how four domain-specific skills (arithmetic procedural skills, number fact retrieval, place value concept, and number sense) and two domain-general processing skills (working memory and processing speed) may account for Chinese children's mathematics learning difficulties. Children with mathematics difficulties (MD) of two age groups (7–8 and 9–11 years) were compared with age-matched typically achieving children. For both age groups, children with MD performed significantly worse than their age-matched controls on all of the domain-specific and domain-general measures. Further analyses revealed that the MD children with literacy difficulties (MD/RD group) performed the worst on all of the measures, whereas the MD-only group was significantly outperformed by the controls on the four domain-specific measures and verbal working memory. Stepwise discriminant analyses showed that both number fact retrieval and place value concept were significant factors differentiating the MD and non-MD children. To conclude, deficits in domain-specific skills, especially those of number fact retrieval and place value understanding, characterize the profile of Chinese children with MD.

Introduction

Children with mathematics disabilities appear to constitute a heterogeneous group, with different children showing different profiles of knowledge, learning strengths, and learning deficits (Geary, 2002). This may be the reason why different terminologies have been used. In this study, we set

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out to explore the cognitive profile of Chinese children with marked difficulties in mathematics. We adopted relatively lenient criteria to obtain a reasonably large sample in an exploratory study with little known findings about MD in Chinese. We use the term *mathematics difficulties* (MD), instead of mathematics disorder or mathematics disabilities, to include children having a broader range of difficulties.

Previous research studies have suggested that mathematics disabilities or difficulties tend to be associated with deficits in four domain-specific numerical skills (arithmetic procedural skills, number fact retrieval, place value concept, and number sense) and two domain-general processing skills (working memory and processing speed).

Deficits in domain-specific numerical skills

Arithmetic procedural skills

A deficit in arithmetic procedural skills typically means difficulties in executing arithmetic procedures (e.g., carrying or trading in complex addition problems) or in executing counting procedures to solve simple addition problems (Geary, 1996). For multistep arithmetic problems, the procedural errors may include misalignment of numbers while writing down partial answers or errors in carrying or borrowing from one column to the next (Russell & Ginsburg, 1984). Children with mathematics disabilities or difficulties, in comparison with typically achieving children, tend to use less sophisticated strategies and commit more errors in solving addition problems (Geary, Hamson, & Hoard, 2000; Geary, Hoard, Byrd-Craven, & DeSoto, 2004; Ostad, 1997). However, many of these children improve by the middle of the elementary school years (Geary, 2000; Torbeyns, Verschaffel, & Ghesquiere, 2004). Thus, their error-prone use of immature procedures seems to represent a developmental delay instead of a long-term cognitive deficit. Such delay seems to be domain specific and does not characterize children with other academic-related learning deficits. For example, children with reading disabilities (RD) only do not seem to differ from typically achieving children in their strategies for solving simple addition problems in the accuracy of strategy use (Geary & Hoard, 2002) or in multistep calculation (Reikeras, 2006).

Number fact retrieval

A deficit in number fact retrieval means difficulties in accessing arithmetic facts from long-term memory (Geary, 2004). According to Geary's conceptual framework, the difficulties of storing arithmetic facts are related to the limitations of MD children in retaining information in working memory while performing other operations. For example, in doing a simple addition task of 5 + 2, children with MD may favor the "counting all" strategy that refers to counting from 1, 2, 3, . . . instead of counting up or on from the higher number: 5, 6, 7. The counting procedure may influence formation of long-term memory representations of basic facts if activation of numerical representations in working memory decays more quickly for children with MD. In this situation, the representation of the problem addends may decay before the count is completed; thus, an association between the problem stem (e.g., 5 + 2) and the answer generated by means of counting might not be formed in long-term memory. A second form of retrieval deficit may need to do with difficulties in inhibiting the retrieval of irrelevant associations. For example, children with learning disorders more often incorrectly answer the question 6 + 2 = ? with 7 or 3, each of which is a number following an addend in the counting string, than their typically achieving peers (Geary et al., 2000). Indeed, deficits of number fact mastery among MD children seem to be rather persistent and are quite independent of reading and language abilities (Jordan, Hanich, & Kaplan, 2003a). Number fact retrieval deficits increasingly emerge as a central characteristic of mathematics disabilities, at least with respect to addition and subtraction operations (Geary, 2004; Gersten, Jordan, & Flojo, 2005; Jordan, Hanich, & Kaplan, 2003b; Ostad, 1998; Robinson, Menchetti, & Torgesen, 2002).

Although arithmetic procedural deficit in children with MD may prove to be a developmental delay, number fact retrieval deficit seems to persist. In the current study, we compared younger and older children with MD to examine the persistence of these and other cognitive deficits.