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ScienceDirect
Cognition 102 (2007) 361–395
COGNITION
www.elsevier.com/locate/COGNIT

Basic numerical skills in children with mathematics learning disabilities: A comparison of symbolic vs non-symbolic number magnitude processing ☆

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Received 6 May 2005; revised 9 January 2006; accepted 10 January 2006

Abstract

Forty-five children with mathematics learning disabilities, with and without comorbid reading disabilities, were compared to 45 normally achieving peers in tasks assessing basic numerical skills. Children with mathematics disabilities were only impaired when comparing Arabic digits (i.e., symbolic number magnitude) but not when comparing collections (i.e., non-symbolic number magnitude). Moreover, they automatically processed number magnitude when comparing the physical size of Arabic digits in an Stroop paradigm adapted for processing speed differences. Finally, no evidence was found for differential patterns of performance between MD and MD/RD children in these tasks. These findings suggest that children with mathematics learning disabilities have difficulty in accessing number magnitude from symbols rather than in processing numerosity per se.

Keywords: Mathematical disabilities; Learning disabilities; Dyscalculia; Mathematical development; Number semantic; Number magnitude

☆ This manuscript was accepted under the editorship of Jacques Mehler.

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doi:10.1016/j.cognition.2006.01.005

1. Introduction

Numbers are a pervasive feature of our everyday life. From early childhood, children develop in an environment rich in quantitative information and numerical experiences. They hear adults using numbers to count, measure, when they use money, tell the time and give the date; they see Arabic symbols in shops, streets, and games as well as on cars, on the pages of books, and on television. Very early on, they become able to count on their own, to grasp the quantitative relationship between collections and to compute small calculations. Not being able to count efficiently, to understand the meaning of numbers, or to calculate as other children do, rapidly becomes a handicap, not only at school but also in society in general, in the same way as not being able to read.

Temple (1992) defines mathematical disability (MD) as a "disorder of numerical competence and arithmetical skill which is manifest in children of normal intelligence who do not have acquired neurological injuries". Epidemiological studies showed that this learning deficit is as widespread as reading disorders and affects 3.5–6.5% of the school-age population depending on the country of study (Badian, 1983; Gross-Tsur, Manor, & Shalev, 1996; Kosc, 1974; Lewis, Hitch, & Walker, 1994). However, despite the growing interest observed over these last few years, research on MD is actually much less advanced than on dyslexia. One reason is probably the mosaic nature of mathematics which involves an increasing range of skills as children grow up. As a result, mathematical disabilities can take many different forms and can be generated or accentuated by a variety of related cognitive deficits.

In spite of this diversity, there is general agreement about the main behavioural manifestations of MD. Most MD children exhibit problems in the execution of arithmetical procedures and experience difficulties in learning and/or retrieving arithmetic facts from semantic memory (as manifested by a high frequency of computational/retrieval errors and low computational/retrieval speed) which, in turn, contribute to the persistence of immature problem-solving strategies such as verbal or finger counting (Geary, Bow-Thomas, & Yao, 1992; Geary, 1993; Geary, Brown, & Samaranayake, 1991; Geary, Hamson, & Hoard, 2000; Geary, Hoard, Byrd-Craven, & DeSoto, 2004; Hanich, Jordan, Kaplan, & Dick, 2001; Jordan & Hanich, 2003; Jordan & Montani, 1997; Jordan, Hanich, & Kaplan, 2003; Landerl, Bevan, & Butterworth, 2004; Russell & Ginsburg, 1984).

1.1. The question of etiology: A combination of genetic and environmental influences

Family and twin studies have stressed the importance of genetic factors in the etiology of MD. The examination of concordance rates in family members using a large MD classification criterion (<25th percentile on a standardized test) showed that more than half of the parents and siblings (53% for both groups) of an MD child also presented difficulties in mathematics (Shalev et al., 2001). A twin study using a more stringent MD classification criterion (<7th percentile on a standardized test) showed that 58% of monozygotic and 39% of dizigotic co-twins of an MD child were also classified as MD, that is, a prevalence about tenfold higher than that observed in