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Cognition 103 (2007) 23–33
COGNITION
www.elsevier.com/locate/COGNIT

The role of language in mathematical development: Evidence from children with specific language impairments ☆

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Received 10 May 2005; revised 15 February 2006; accepted 20 February 2006

Abstract

A sample ($n = 48$) of eight-year-olds with specific language impairments is compared with age-matched ($n = 55$) and language matched controls ($n = 55$) on a range of tasks designed to test the interdependence of language and mathematical development. Performance across tasks varies substantially in the SLI group, showing profound deficits in production of the count word sequence and basic calculation and significant deficits in understanding of the place-value principle in Hindu-Arabic notation. Only in understanding of arithmetic principles does SLI performance approximate that of age-matched-controls, indicating that principled understanding can develop even where number sequence production and other aspects of number processing are severely compromised.

Keywords: Language development; Mathematical development; Specific language impairments

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

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0010-0277/$ - see front matter
doi:10.1016/j.cognition.2006.02.007

1. Introduction

Evidence from a variety of research areas indicates the involvement of language in mathematical cognition. Spelke and Tsivkin (2001) report language-specific advantages in bilingual adults given training in arithmetic fact retrieval. Exact arithmetic tasks showed benefits only in the language of training, while approximate arithmetic showed equal benefits in both trained and untrained languages. Convergent findings from neuroimaging and ERP studies (Dehaene, Spelke, Pinel, Stanescu, & Tsivkin, 1999; El Yagoubi, Lemaire, & Besson, 2003), and from brain-damaged patients (Lemer, Dehaene, Spelke, & Cohen, 2003) suggest that the brain-based systems supporting approximate and exact arithmetic may be separable, and that representation of exact number may recruit language-related networks (Dehaene, Molko, Cohen, & Wilson, 2004; Dehaene, Piazza, Pinel, & Cohen, 2003).

Recent cross-linguistic studies (Gordon, 2004; Pica, Lemer, Izard, & Dehaene, 2004), based on languages which lack number words, indicate that exact number representation depends very largely on the availability of a number word sequence, while approximation systems appear to operate independently. Where number word sequences are established, cross-linguistic variation in the structure of the spoken sequence has substantial effects on learning and may influence conceptual understanding (Miller, Kelly, & Zhou, 2004; Miura, 1987; Miura & Okamoto, 2003).

The integration of preverbal and verbal systems in the development number processing is currently the focus of much debate. Carey (2004) proposes that linguistic factors play a crucial bootstrapping role in the development of number concepts, through early experience of number-relevant language (Hodent, Bryant, & Houdé, 2005), and subsequently through integration of the number word sequence with symbolic representations of small sets of items. A contrasting view is offered by Gelman and Butterworth (2005), who propose that numerical cognition is ontogenetically independent, and argue that conceptual understanding does not depend on number word knowledge (Sarnecka & Gelman, 2004).

Landerl, Bevan, and Butterworth (2004) examined the role of language in the development of mathematical skills by comparing children with selective deficits in reading or arithmetic, and a dual deficit group, with typically developing children. Performance on a range of basic number processing tasks indicated similar patterns of broad-ranging and substantial impairment in both the arithmetic-only and dual deficit groups, but not in the reading-only group. Theses findings suggest that basic number processing deficits underlie arithmetic deficits, and, importantly, that reading deficits do not substantially influence number processing. The close developmental relation between reading and language difficulties (Bishop & Snowling, 2004) supports the extended interpretation that language and number are developmentally separable. While acknowledging that phonological aspects of some tasks (number naming and number sequence production) may have affected the performance of their reading deficit group, Landerl et al. (2004) argue that basic number representation (as indicated, for example, by number comparison) is not compromised.

Hanich, Jordan, Kaplan, and Dick (2001) also compared children with selective deficits and typically developing children and have subsequently reported their pro-