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Low working memory capacity impedes both efficiency and learning of number transcoding in children

Valérie Camos *

LEAD–CNRS, Université de Bourgogne and Institut Universitaire de France, Pôle AAFE, Esplanade Erasme, B.P. 26513, 21065 Dijon Cedex, France

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Abstract

This study aimed to evaluate the impact of individual differences in working memory capacity on number transcoding. A recently proposed model, ADAPT (a developmental asemantic procedural transcoding model), accounts for the development of number transcoding from verbal form to Arabic form by two mechanisms: the learning of new production rules that enlarge the range of numbers a child can transcode and the increase of the mental lexicon. The working memory capacity of 7-year-olds was evaluated along with their ability to transcode one- to four-digit numbers. As ADAPT predicts, the rate of transcoding errors increased when more production rules were required and when children had low working memory capacity, with these two factors interacting. Moreover, qualitative analysis of the errors produced by high- and low-span children showed that the latter have a developmental delay in the acquisition of the production rules.

Keywords: Working memory; Number transcoding; Procedural system; Individual differences

Introduction

Working memory is considered to be the "workbench of cognition" (Jarrold & Towse, 2006; Klatzky, 1980). Indeed, working memory capacity refers to the ability to hold

* Fax: +33 380 39 57 67.
E-mail address: valerie.camos@u-bourgogne.fr

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information in mind while maintaining other information to achieve a cognitive task. Thus, variation in this capacity is related to performance in any cognitive activity. However, individual differences in working memory capacity are studied mostly in complex activities such as problem solving, reasoning, and text comprehension. The current study aimed to evaluate the impact of individual differences in a relatively simple task, namely, number transcoding. Although transcoding from a verbal form to an Arabic number chain is an everyday activity, children exhibit specific errors, especially at the beginning of the learning process. However, very few studies have investigated the development of this activity. A new model called ADAPT (a developmental asemantic procedural transcoding model) was proposed recently to account for these errors and to describe the ongoing processing steps in transcoding (Barrouillet, Camos, Perruchet, & Seron, 2004). The aim of the current article is to document number transcoding in children and to examine how individual differences in working memory capacity could affect this process.

Individual differences in working memory capacity

A large number of studies have shown that working memory spans, measures of an individual's working memory capacity, reliably predict performance in national curriculum tests evaluating both language and mathematical skills (e.g., Gathercole & Pickering, 2000; Gathercole, Pickering, Knight, & Stegmann, 2004; Lépine, Barrouillet, & Camos, 2005). Furthermore, some of the academic difficulties encountered by children with or without learning disabilities could result from their low working memory capacities (Bull, Johnston, & Roy, 1999; Bull & Scerif, 2001; Geary, Brown, & Samaranayake, 1991; Geary, Hoard, & Hamson, 1999; McLean & Hitch, 1999).

Three major accounts have been proposed to explain why working memory capacity measures are such a good predictor of human cognitive functioning (Cowan, 2005; Jarrold & Towse, 2006). First, some models suggest that working memory measures evaluate the efficiency of processing. Daneman and Carpenter (1980), and Case, Kurland, and Goldberg (1982) proposed that the reading or counting span—that is, the number of items that can be maintained for further recall while reading sentences or counting arrays of dots—depends on the cognitive demands of the reading or counting process. Second, some studies have shown that working memory capacity measures reflect variations in individuals' storage capacity independently of processing efficiency (Bayliss, Jarrold, Baddeley, Gunn, & Leigh, 2005; Bayliss, Jarrold, Gunn, & Baddeley, 2003; Fry & Hale, 2000; Oberauer, Süβ, Wilhelm, & Wittmann, 2003). Third, recent accounts of working memory equate its capacity with the amount of attentional resources. These resources could be allocated specifically to retrieve information from long-term memory (Cowan, 1999; Lovett, Reder, & Lebière, 1999), to engage in both processing and storage (Barrouillet, Bernardin, & Camos, 2004; Barrouillet & Camos, 2001), to control attention in the face of interference (Engle, Tuholski, Laughlin, & Conway, 1999; Hasher, Zachs, & May, 1999; Kane & Engle, 2003; Saito & Miyake, 2004), or to hold multiple items simultaneously (Cowan, 2001).

Usually, the impact of individual differences in working memory is evaluated in high-level cognitive tasks because they involve multiple-step processing for which the duration and efficiency of each step determine overall performance and because they require both the retrieval of large amounts of information and the storage of information in the face of interfering and distracting inputs. Thus, even simpler tasks that rely on the retrieval