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Working memory in children with reading disabilities

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Abstract

This study investigated associations between working memory (measured by complex memory tasks) and both reading and mathematics abilities, as well as the possible mediating factors of fluid intelligence, verbal abilities, short-term memory (STM), and phonological awareness, in a sample of 46 6- to 11-year-olds with reading disabilities. As a whole, the sample was characterized by deficits in complex memory and visuospatial STM and by low IQ scores; language, phonological STM, and phonological awareness abilities fell in the low average range. Severity of reading difficulties within the sample was significantly associated with complex memory, language, and phonological awareness abilities, whereas poor mathematics abilities were linked with complex memory, phonological STM, and phonological awareness scores. These findings suggest that working memory skills indexed by complex memory tasks represent an important constraint on the acquisition of skill and knowledge in reading and mathematics. Possible mechanisms for the contribution of working memory to learning, and the implications for educational practice, are considered.

Keywords: Reading disabilities; Working memory; Short-term memory; IQ; Mathematics

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Introduction

The purpose of this study was to investigate the extent to which impairments of working memory contribute to the severity of the learning difficulties experienced by children with reading disabilities. Although close links between memory function and many aspects of learning and academic achievement in unselected samples of children are well established, the degree to which working memory function constrains learning progress in children with learning disabilities is less well understood. The study focused in particular on the extent to which impairments of working memory contribute to the problems in both reading and mathematics commonly experienced by children with learning disabilities and on whether any associations that are found could be mediated by other aspects of cognitive function.

Immediate memory involves several related subsystems of memory. The capacity to store material over short periods of time in situations that do not impose other competing cognitive demands is typically referred to as short-term memory (STM). Findings from experimental, developmental, and neuropsychological studies indicate that STM is fractionated into at least two domain-specific components that are specialized for the retention of phonological and visuospatial material (for reviews, see Gathercole, 1999; Vallar & Papagno, 2002). In the influential working memory model of Baddeley and Hitch (1974), developed subsequently by Baddeley (1986, 2000), these components correspond to different slave systems. The phonological loop retains material in a phonological code that is highly susceptible to time-based decay, and the visuospatial sketchpad has limited capacities to represent information in terms of its visual and spatial characteristics. The phonological loop is assessed using methods such as the recall of digit or word sequences, and visuospatial sketchpad functioning is typically measured by tasks involving the recall or recognition of visual patterns or sequences of movement.

Working memory is related to, but distinguishable from, STM. The term is widely used to refer to the capacity to store information while engaging in other cognitively demanding activities, and it is most commonly assessed using complex memory paradigms that impose demands for both temporary storage and significant processing activity with selected task components varied across domains. An example of a complex memory task is listening span, where participants are asked to make a meaning-based judgment about each of a series of spoken sentences and then to remember the last word of each sentence in sequence (e.g., Daneman & Carpenter, 1980). Another task is counting span, where participants are asked to count target items in successive arrays and then to recall in sequence the tallies of the arrays (Case, Kurland, & Goldberg, 1982). Despite disparate processing demands, scores on the two tasks are highly correlated (e.g., Gathercole, Pickering, Ambridge, & Wearing, 2004) and are also linked with performance on memory updating tasks that are believed to tap working memory (Jarvis & Gathercole, in press; Miyake et al., 2000).

Most theoretical accounts of immediate memory incorporate a distinction between the storage-only capacities of STM and the broader and more flexible nature of working memory. In addition to the domain-specific storage systems of the phonological loop and the visuospatial sketchpad, the Baddeley and Hitch (1974) model includes the central executive, responsible for a range of functions such as retrieval of information from long-term memory, regulation of information within working memory, attentional control of both encoding and retrieval strategies, and task shifting (Baddeley, 1986, 1996). Proponents of the working memory model have suggested that the storage demands of complex memory