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Verbal working memory and reading abilities among students with visual impairment☆

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ABSTRACT

Aim: This study investigated the relationship between working memory (WM) and reading abilities among students with visual impairment (VI). Seventy-five students with VI (visually impairment and blindness), aged 10–15 years old participated in the study, of whom 44 were visually impaired and 31 were blind.
Methods: The participants' reading ability was assessed with the standardized reading ability battery Test-A (Padeliadu & Antoniou, 2008) and their verbal working memory ability was assessed with the listening recall task from the Working Memory Test Battery for Children (Pickering et al., 2001).
Results-Implications: : Data analysis indicated a strong correlation between verbal WM and decoding, reading comprehension and overall reading ability among the participants with VI, while no correlation was found between reading fluency and verbal WM. The present study points out the important role of verbal WM in reading among students who are VI and carries implications for the education of those individuals.

What this paper adds?

Learning to read comprises the achievement of two stages —that of decoding and that of text comprehension. Although decoding and reading comprehension are related skills, research data support the gradual dissociation of the second from the first and show that other factors, such as working memory (WM), affect comprehension more than decoding skills. However, limited research has been focused on the relationship of reading and WM in children with visual impairments. As an effort to address this gap in knowledge, the aim of this study was to examine the relationship between verbal WM and reading abilities among students with VI. Although visual retention and processing of information are also important for reading, when visual input is only partly available as in the case of VI individuals, the retention and process of verbal information should be important for reading. The following research hypotheses were set in present study: 1) verbal WM is related to decoding in children with VI and blindness, 2) verbal WM is related to reading fluency 3) verbal WM is related to reading comprehension. Based on the findings of the present study the relationship between reading comprehension and verbal WM in children with VI was strong. According to the present results it can be suggested that experimental studies are needed to be conducted to see if WM improves reading improves as well and then propose that children

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with VI may be benefited by a working memory training programme that may increase their working memory capacity improving their WM function and consequently their ability to read and most importantly to comprehend written texts.

1. Reading and working memory

Reading is a complex procedure if one considers the number of functions that need to be activated and applied for its achievement. Learning to read comprises the achievement of two stages—that of decoding and that of comprehension (De Jong and van der Leij, 2002). Although decoding and reading comprehension are related skills (Gough and Tunmer, 1986), several studies suggest the gradual dissociation of the second from the first (De Jong and van der Leij, 2002; Megherbi & Ehrlich, 2005; Muter, Hulme, Snowling, & Stevenson, 2004; Savage, 2006; Stothard & Hulme, 1996; Tunmer and Hoover, 1992). This tendency is mostly observed as the age of children increases. Studies such as those of Oakhill, Cain, & Bryant, 2003 showed that factors such as vocabulary, Working Memory and knowledge of the structure of the text, affect comprehension more than decoding skills. Perfetti and Hart (2002) and Landi (2005) found similar findings in various age groups. Finally, the fluency of reading ability intervenes in comprehension processes, but only during the first years of the child's reading efforts. The direct relation between word processing speed and comprehension is a crucial element of fluency in the total comprehension process (Allington, 2004; Jenkins, Fuchs, van den Brock, Espin, & Deno, 2003), which is necessary but not sufficient for the reader to comprehend the message communicated by the writer of the text (De Jong and van der Leij, 2002). Working memory (WM) is a memory system of limited capacity, which is responsible for retention and simultaneous processing of information over short periods of time (Baddeley and Logie, 1999 Just & Carpenter, 1992). WM is generally considered as a temporary storage system under attentional control that is the basis for our capacity for complex thought (Baddeley, 2012).

According to the multi-component model of WM suggested by Baddeley and Hitch (1974) and Baddeley (2003a, 2003b), WM consists of four subsystems: a) the phonological loop that allows the temporary storage of verbal and acoustic information, such as phone numbers and people's names, b) the visuospatial sketchpad that allows the manipulation and storage of visuospatial information. Research supports that the visual spatial sketchpad of WM involves two functions: i) one function responsible for the maintenance and storage of special categories of optical information (such as shapes and colors) and ii) one function responsible for retaining of spatial information in relation to the element of dimension in space (e.g., the course taken in a labyrinth, or the place of an object in space) (Gathercole and Baddeley, 1993; Logie, 1995; Pickering et al., 2001). iii) The third subsystem is the central executive system, a higher order attentional control system that is in direct contact with the phonological loop and the visual-spatial sketchpad and coordinates the activity among all subsystems and the forth system is iv) the episodic buffer: a limited capacity system that provides temporary storage of information held in a multimodal code and binds information from the subsidiary systems, and from long-term memory, into a unitary episodic representation (Baddeley, 2000).

Typically, with the term working memory we refer to the retention and the parallel processing of information. Thus we imply to the capacity of the central executive component of working memory, while with the term short-term memory we refer to the mere retention of information and thus, we mean the capacity of the phonological loop and visuospatial sketchpad. Several others models describing the structure of working memory have been suggested (see Miyake and Shah, 1999 for an overview) nevertheless the Baddeley and Hitch (1974) models remain a very widely used and influential in current literature. Also, it describes working memory capacity in full detail, suggesting distinctive components for different functions and activities. It has been used a lot with research among clinical populations (Gathercole and Pickering, 2000; Gathercole & Pickering, 2001) and in educational settings (Holmes and Gathercole, 2014 Dunning & Holmes, 2014).

As WM is responsible for the temporary retaining and processing of information, it appears to be necessary for transacting cognitive processes such as numeration (Logie and Baddeley, 1987) and logical inference (Cowan, Cartwright, Winterowd, & Sherk, 1987; Miyake and Shah, 1999). Furthermore, research has consistently demonstrated significant relationships between WM and many aspects of language development, such as vocabulary acquisition (Baddeley, Gathercole, & Papagano, 1998), learning of a foreign language (Service, 1992 Service & Kohonen, 1995) and reading (Daneman and Carpenter, 1980) with an emphasis on text comprehension (Oakhill, 1982; Oakhill, Yuill, & Parkin, 1986).

Al-Hamori and Khsawneh (cited in Al-Yaman, Al-Srour, & Al-Ali, 2013) explicitly examined the role of working memory capacity and gender in reading comprehension in a sample of 230 students in secondary school in Irbid city. In their study they found that reading comprehension is affected by the capacity of working memory, and that there was no interaction effect between working memory capacity and gender. Jincho et al. (2008) investigated the effects of verbal working memory (VWM) and cumulative linguistic knowledge (CLK) on reading comprehension among 62 students in Useda University in Japan. According to the results VWM and CLK were independent of each other, while verbal working memory and cumulative linguistic knowledge independently contributed to reading comprehension.

The embodiment of information from different parts of the text is very difficult and demands good memory skill. The limits of memory systems may impose problems in decoding, in recall and/or in the processing of new information in the text in relation to pre-existing knowledge (Cornoldi, de Beni, & Pazzaglia, 1996; Perfetti, Marron, & Foltz, 1996; Yuill, Oakhill, & Parkin, 1989). Theories that claim the necessity of accuracy and speed in word reading in order for comprehension to be successful are based on the function of an immediate memory system.

Initially, the capacity of WM was examined by a sentence-based reading span test developed by Daneman and Carpenter (1980, 1983).This task requires participants to read and make semantic judgments on sentences, while at the same time they asked to recall the last word of each sentence. Results showed that performance on this task correlates higher with measurements of reading comprehension rather than other memory tests. Over time this task was developed further and adapted to recent models of working