Impact of memory on school performance

Elmir Mohammed
mohammed.elmir1@usmba.ac.ma
Department of Psychology, Faculty of Letters and Human Sciences Dhar Mahraz, Sidi Mohamed Ben Abdellah University, Fes- Morocco

Abstract

The present work reviewed the research results related to the impact of memory on academic achievement. The research in the relationships between memory and school learnings does not began until 1990s. Abounding and cumulative data showed that memory deficits produce difficulties in different academic domains such as reading and mathematics. This paper surveyed the effect of memory on academic achievement; it examined the role of many memory structures such as, long-term memory (LTM), short-term memory (STM) and working memory (WM) in school achievement. But the focus will be directed toward the correlations between WM and performance in learning tasks.

The majority of studies dealing with relationships between working memory and academic achievement adopted the Baddeley and Hitch’s model (1974). It appeared that the predictive power of WM in academic achievement overrides intelligence tests. Data showed that WM influences many school learnings like reading and mathematics. However, we prioritize the impact of WM resources on word recognition and reading comprehension. We also presented some data concerning the effect of WM on reading in Arabic; it turns out that WM capacity conditioned performance in word recognition and reading comprehension in this language. Additionally, it is confirmed that WM capacity determined some aspects of reading activity such as word recognition speed in Arabic. It was concluded that measures of WM could be used to predict performance in different cognitive tasks like reading.

Keywords: memory; academic achievement; working memory; reading.

تأثير الذاكرة على الأداء الدراسي

محمد المير
mohammed.elmir1@usmba.ac.ma
شعبة علم النفس، كلية الآداب والعلوم الإنسانية، ظهر المهراز، جامعة سيدي محمد بن عبد الله، فاس، المغرب.

ملخص

تستعرض الدراسة الحالية نتائج الأبحاث التي تناولت دور الذاكرة في الأداء الدراسي. وقد تأخر الاهتمام بدور الذاكرة في الأداء الدراسي، إذ أن البحث في الارتباطات بين الذاكرة والتعلمات المدرسية لم يبدأ سوى في التسعينات 1990S. وأوضحت معطيات متواترة أن القصورات الذاكرية تؤدي إلى صعوبات في مجموعة من المهمات المدرسة كالرياضيات والقراءة.

واستعرضت هذه الورقة تأثير الذاكرة على الأداء الدراسي، إذ فحصنا أدوار الذاكرة البعيدة المدى والذاكرة القصيرة المدة والذاكرة العاملة في الأداء الدراسي. لكن سيجري التركيز على الارتباطات بين الذاكرة العاملة والأداءات في المهمات التعلمية. وقد انتظمت معظم هذه الدراسات التي تناولت العلاقة بين الذاكرة العاملة والأداء الدراسي في إطار نموذج بادلي وهيتش (1974). وقد اتضح أن القوة التنبؤية للذاكرة العاملة بالأداء الدراسي تفوق قياسات الذكاء. وتبين أن الذاكرة العاملة تؤثر في مجموعة من التعلمات المدرسية كالقراءة والرياضيات. وسيجري التركيز أساسا على تأثير موارد الذاكرة العاملة على التعرف على الكلمات والفهم القرائي. وهناك معطيات عن دور الذاكرة العاملة في القراءة في اللغة العربية، إذ تشرط قدرة الذاكرة العاملة الأداء في التعرف على الكلمات والفهم القرائي في العربية. وقد تبين من معطيات متراكمة تأثير قدرة الذاكرة العاملة على بعض أوجه الأداء القرائي كسرعة التعرف على الكلمات. ويمكن استخلاص أن قياسات الذاكرة العاملة يمكن أن تستعمل للتنبؤ بالأداء في مجموعة من المهمات المعرفية كالقراءة.

الكلمات المفتاحية: الذاكرة؛ الذاكرة العاملة؛ الأداء الدراسي؛ القراءة.

Introduction

The interest in studying memory rekindled with the arrival of the cognitive revolution in the 1950s. While Behaviourism paradigm rejected the study of mental events that occur between stimuli and responses and focused on observable behaviors, cognitive psychology investigated mental processes such as memory, perception ... One of the foundational works in cognitive paradigm concerned human memory (Miller, 1956), it was presented at the MIT conference in 1956. Additionally, Neisser defined cognitive psychology as the science which deals with the study of all processes by which the sensory input is transformed, reduced, elaborated, stored, recovered, and used (Neisser, 1967). This definition refers explicitly to the processes of human memory, which are encoding, storage and retrieval.

Since then, many models of memory functioning were proposed, like the model of Waugh and Norman (1965) and the model of Atkinson and Shiffrin (1968). Furthermore, human memory is considered as a complex cognitive system that comprise various structures [5] and processes that contribute to information processing. The progress in understanding memory leads to investigating its role in multiple related areas like learning to read, mathematics and generally in school success or academic achievement.

Our main interest in this paper is to analyse the research data that studied the impact of memory in school performance; accordingly, we will address the following points:

1- The role of memory in school performance, especially its impact on some academic domains.

2- the contribution of some memory structures such as short-term memory (STM), long-term memory (LTM) and working memory (WM) in school abilities.

3- The effect of WM on reading, particularly its role in word recognition and reading comprehension.

4- The impact of WM on reading in Arabic language.

The rationale behind this interest on the role of memory structures in school emanate from its huge involvement in learning activities. So, we aim to uncover how WM affects academic achievement. Moreover, our primary goal in this study consists in exploring the relationships between memory and school performance. Wherefore, we will review previous data concerning the effect of memory on student’s achievement.

[5] The complexity of human memory appears in the multiplicity of its structures, it includes sensory memory (SM), STM, LTM, and WM. These structures contain multiple substructures; thus, SM comprises iconic memory and echoic memory; whereas STM is constituted by auditory STM and visual STM; besides, LTM is divided into declarative memory and procedural memory. Declarative memory encompasses semantic memory and episodic memory; whilst procedural memory includes skills, priming, primary associative learnings, non-associative learnings (reflexes). The central memory structure, which is WM consists of phonological loop, visuo-spatial sketchpad, central executive and episodic buffer. In addition, memory processes include encoding, storage and retrieval. These various structures, substructures and processes are strongly involved in cognitive functioning.

I- Memory and academic achievement

Memory plays a crucial role in information processing. Thus, it is asserted that there is a memory deficit behind any learning difficulty (Gathercole et al., 2006). Indeed, research in the impact of memory on academic achievement was neglected until the 1990s (DeMarie & Lopez, 2014). We found no works that studied the relationships between memory and academic achievement before 1995; but there was an increase in the number of studies that investigated memory and academic achievement between 2005 and 2010 (DeMarie & Lopez, 2014)[6]. This does not deny that many studies examined the correlations between memory and other subfields of academic achievement such as learning to read, mathematics... This active research movement explored the contribution of STM, LTM and WM to academic achievement; although the latter was the most studied structure.

Notwithstanding the paucity of works that examined the contribution of LTM to academic achievement, it is proven that LTM, the store of knowledge and experiences, conditioned learning and academic success (Bunge, 2016); for example, it is involved in language comprehension (Kutas & Federmeier, 2000), reading (Blankenship, O'Neill, Ross, & Bell, 2015 ؛ Mirandola, Del Prete, Ghetti, & Cornoldi, 2011), mathematics (Blankenship et al., 2015, in Bunge, 2016). As a consequence of the fact that the development and functioning of LTM depend on WM (Dehn, 2008), it was concluded that WM determines the rate and the scope of learning (Dehn, 2008).

For that reason; there was a huge interest on the effect of STM and WM on academic achievement during the last decades (Swanson, Cooney, & McNamara, 2004, in Swanson & Zheng, 2009). While STM is a structure which its function consists only in maintaining information; WM combined maintenance and manipulation of information (Baddeley & Hitch, 1974; Baddeley & Logie, 1999).

Concerning the effect of STM on academic achievement it appears that children who struggle with reading face difficulties in tasks that necessitate short-term maintenance of information in the order of presentation such as digit span and word span (McDougall, Hulme, Ellis, & Monk, 1994 ؛Swanson, Cooney, & O'Shaughnessy, 1998). This deficit could be attributed to deficits in rehearsal mechanism in STM (Henry & Millar, 1993). Another set of data showed that short term phonological storage plays crucial role in word recognition (Jorm, 1983). Likewise, there was findings that revealed that STM tasks such as digit span and word span, permit to distinguish between good and poor readers (Torgesen & Houck, 1980). This conclusion was corroborated by recurrent results that found that digit span subtest in Wechsler intelligence scale allows detection of children with reading difficulties (Mishra, Shitala, Ferguson, & King, 1985). furthermore, there was a disagreement between researchers concerning the relationships between STM and WM; so while some of them deemed that STM can be considered similar to phonological loop in

[6] DeMarie and Lopez (2014) do not found any work about the relationships between memory and academic achievement before 1995; but they counted more than 33 works between 2005 and 2010 that investigated those relationships.

Baddeley and Hitch's model of WM (Baddeley, 1986; Baddeley, Gathercole, & Papagano, 1998; Bayliss, Jarrold, Baddeley, & Leigh, 2005); other authors denied that WM includes STM (Engle, Tuholski, Laughlin & Conway, 1999).

Although the debate about the relationships between STM and WM, and the possibility that STM could be considered as a substructure of WM like phonological loop; some studies found that tasks of STM can't make differences in academic achievement, for example between good and poor readers (Felton & Brown, 1991). Other results deduced that deficits in STM processes such as rehearsal and chunking do not lead to reading difficulties (Cohen, 1981; Swanson, 1983a, 1983b). furthermore, other studies do not find any correlation between STM and performance in verbal tasks and mathematics (Chiang & Atkinson, 1976).

Generally, it is claimed that there are weak relationships between STM and performance in cognitive tasks. Taking into account the contradictions in the correlations between STM and academic achievement, and the fact that some researchers considered STM as a component of WM (Baddeley, 1986); we will focus in this review on the role of working memory in academic achievement particularly in reading.

II- Working memory and academic achievement

Traditionally, the common psychometric process to which children with weak academic achievement are submitted is Intelligence scale; supposedly because IQ (Intelligence Quotient) correlated positively with school success. So, there was a spread use of intelligence tests in detection of Learning disabilities. But this approach was criticized (Dehn, 2008). It has been demonstrated that measures of WM capacity predict better school success than Intelligence tests (Alloway et al., 2005; Gathercole, Alloway, Willis & Adams, 2006, Swanson, 2004, in DeMarie & Lopez, 2014). Although modern Intelligence tests contain some WM tasks, intelligence tests are often decried for being more culturally biased than WM tests.

Research in the links between WM and academic achievement are based on Baddeley and Hitch's model of WM, which was developed by Baddeley and Hitch (1974) and revised later (Baddeley, 1986, 2000), along with the model of general capacity of WM (Turner & Engle, 1989). WM span measures are supposed to explain individual differences in learning (Gathercole, Lamont, & Alloway, 2006; Swanson, Cochran, & Ewers, 1990). Moreover, it was asserted that learning disabilities are related to WM capacity deficiencies (Henry, 2001; Swanson & Alexander, 1997; Swanson & Berninger, 1996; Swanson & Siegel, 2001).

WM capacity can predict performance in many cognitive tasks (Engle, 2002; Swanson, 1993); moreover, it correlates significantly with performance in word recognition, reading comprehension, spoken language comprehension, following directions, vocabulary development, written expression and reasoning (Engle, 1996; Engle, Tuholski, Laughlin & Conway,1999, in Dehn, 2008, p. 93). It is also discovered that deficits in WM lead to errors in some learning tasks like remembering and carrying out instructions and mental arithmetic (Gathercole, Lamont & Alloway, 2006). Additional data confirm that weak WM drastically alters learning English and mathematics (Alloway et al., 2005; Bull & Scerif, 2001; Gathercole, Pickering, Knight & Stegmann, 2004; Swanson, 1999; Jarvis & Gathercole, 2003)

Likewise, it has been demonstrated that children who struggle with English and mathematics have poor WM span (Gathercole & Pickering, 2000). However, a greater part of research in correlations between WM and academic achievement targeted the role of WM in language processing especially in reading.

III- Working memory and reading

Undoubtedly reading becomes in the centre of a huge industry in modern era: The education. All learnings are based in large part on it, and are affected by success or failure in its acquisition. Statistics from U.S. Department of Education revealed that 2.9 million children or 5.5% of schooled children suffer from specific learning disabilities (U.S. Department of Education, 2006, in Dehn, 2008). It appears also that 80% of learning disabilities are reading disorders (Meyer, 2000).

While reading disabilities put at risk the academic future of about 4 to 10 % (Del Giudice et al., 2001), early diagnostic of specific learning disabilities, precisely reading disabilities facilitate intervention to booster or compensate defective reading mechanisms, and enable poor readers building pertinent reading skills that ease the processing of the written language.

Moreover, the measures of WM capacity correlate with performance in reading (Carpenter & Just, 1988; Daneman & Carpenter, 1980). The research data also indicated that deficits in some components of WM like phonological loop undermine the development of reading (Fletcher, 1985). Besides that, researchers found significant correlations between word recognition and some complex memory span tasks such as WM span (Daneman & Carpenter, 1980; Gathercole & Pickering, 2000). Besides, reading performance is also highly regulated by WM capacity in children whose ages ranged between 8 and 11 years (Herdman & LeFevre, 1992; Hutton & Towse, 2001).

WM capacity intervenes basically when language processing is not automatized; for example, when the task consists in the recognition of unfamiliar words like new names in the beginning of learning to read. It appears in children between 5 and 9 years that complex memory span tasks are linked to word recognition and reading comprehension (Bayliss, Jarrold, Gunn, Baddeley & Leigh, 2005c). Another set of evidence claimed that accuracy of word recognition and comprehension in 7 years children rely on WM capacity (Leather & Henry, 1994). Furthermore, many researchers assumed that reading disabilities are related to low WM capacity (De Jong, 1998, 2006; Hulme & Mckenzie, 1992; Siegel & Ryan, 1989). it is also argued that WM capacity assessment allows detection of children who will probably struggle with reading disabilities (Swanson et al., 2004).

1- Working memory and word recognition

WM determines performance in many school domains like word recognition and mathematics; consequently, many investigators obtained evidence that linked WM scoring with performance in cognitive processes. This interest in the role of WM in cognitive functioning emerges clearly from the research that aims to explain the correlations between WM capacity and word recognition.

Research in the relationships between word recognition and cognitive processes focused as we have seen earlier on WM, STM, LTM and executive functions. The table below shows the correlations between some cognitive processes and a few school tasks.

Table (1) Cognitive processes highly involved in some domains of academic learning (Dehn, 2008, p. 101)

Reading decoding	Reading comprehension	Written language	Mathematics
Phonological processing	WM	WM	WM
STM	LTM	Executive processing	Fluid reasoning
Visual processing	Executive processing	Processing speed	Visual processing
Sequential processing	Fluid reasoning	Planning	Processing speed
WM			Planning
LTM			

Broadly, learning to read is affected by memory span (Milles & Ellis, 1981). The development of reading ability relies upon the improvement of memory span (Ellis, 1988). Furthermore, deficiencies in WM produced reading disorders in alphabetic and morphemic languages (Mann, 1985; Ren & Mattingly, 1990).

A set of studies showed that performance in reading correlates with WM capacity; for example, it appears that poor readers have low WM capacity (Gathercole, Brown & Pickering, 2003; Gathercole & Pickering, 2000; Gathercole, Pickering, Knight & Stegmann, 2004). Although, deficits in phonological processing emanate from alterations in the function of some subsidiary systems of WM such as phonological loop and visuo-spatial sketchpad; it has been demonstrated that poor readers underwent attentional deficit related to the central executive functioning, and this leads to disturbance in attentional processes that allow the maintenance of pertinent information and inhibition of impertinent information (Swanson & Ashbaker 2000). So, some difficulties in word recognition arise from alterations in the functioning of the mechanisms of activation and inhibition during phonological processing (Stanovich & Siegel, 1994). Moreover, the development of metalinguistic skills is also linked to a normal WM (Oakhill & Kyle, 2000). Therefore, deficits in WM capacity could produce slowness in word recognition (Perfetti, 1985). In spite of the fact that WM isn't the exclusive factor that contributed to Reading disorders; it explains high rates of variability in Reading (Swanson, 2006). For instance, some findings have demonstrated strong relationships between word recognition and working memory capacity (Leather & Henry, 1994; Kail & Hall, 1994; Siegel & Ryan, 1989; Swanson, 1993, 2003; Swanson & Siegel, 2001). WM measures could likewise predict word recognition speed in Arabic (Elmir, 2018), so we can use WM assessment to detect children at risk of disorders in word recognition (Elmir, 2018).

2- Working memory and reading comprehension

Similarly, WM plays a crucial role in reading comprehension; it contributes to the extraction of meaning from the written text or during the construction of a situation model. In this task, the reader recognizes the written words and extract meaning from them; moreover, this process is based on the transfer of meaning from one word to another, and from one sentence to another in order to construct a situation model. In this process, WM enables the storage of intermediate products till processing finished (Baddeley, Wilson & Watts, 1995; Just & Carpenter, 1992). In the same way, it also emerges that WM influences reading comprehension skills, and it has been proved that WM predictive power of reading comprehension outpaced intelligence tests, vocabulary and word recognition (Cain, Oakhill & Bryant, 2004). Indeed, WM explains high rate of variability in reading comprehension (Cain, Oakhill & Bryant, 2004). Additional studies found significant correlations between measures of WM capacity and performance in reading comprehension (Seigneuric, Ehrlich, Oakhill & Yuill, 2000). Moreover, results from studies, that explored the influence of each component of WM on reading comprehension, revealed that verbal WM strongly correlate with reading comprehension more than the visuo-spatial sketchpad (Swanson & Siegel, 2001), albeit these two systems support semantic construction during comprehension.

Another study suggested that poor comprehenders have weak WM capacity, in addition to deficits in executive central (Yuill & Oakhill, 1991). Additionally, it has been observed that poor readers consume the large part of their cognitive resources in low processes such as word cognition; hence there are insufficient resources for the comprehension process. WM also takes part in syntactic and semantic processing of sentences (Liberman, Shankweiler, Liberman, Fowler & Fischer, 1977; Mann, Liberman & Shankweiler, 1980). Furthermore, differences between good and poor comprehenders could be explained by variability in WM capacity (Oakhill et al., 1986; Siegel, 1994); for example, low WM capacity readers face difficulties in deduction and resolution of textual ambiguities.

3- The effect of working memory on reading in Arabic Language

Reading in Arabic language wasn't well studied compared to other alphabetic and non-alphabetic languages. While relationships between reading performance and WM capacity are high in other alphabetic languages in word recognition (Ashbakar & Siegel, 2001; Leather & Henry, 1994; Kail & Hall, 1994; Siegel & Ryan, 1989; Swanson, 1993, 2003; Swanson & Ashbakar, 2000) and in reading comprehension (Baddeley, 1997; Daneman & Carpenter, 1980; Goff, Pratt & Ong, 2005; Just & Carpenter, 1992; Montgomery, 2003; Oakhill, 1982; Oakhill, Yuil & Parkin, 1986; Seigneuric et al., 2000; Seigneuric & Ehrlich, 2005; Swanson, 1999b); we know little about correlations between word recognition, reading comprehension and WM in Arabic orthography.

On the one hand, findings from many studies highly correlate WM with reading in Arabic Language (Abu-Rabia, 1995; Abu-Rabia, Share & Mansour, 2003; Abu-Rabia & Siegel, 2003). On the other hand, measures of WM can predict reading performance in Arabic (Elmir, 2018). Thus, children with high WM scores performed well than low

WM scores children in word recognition and reading comprehension. It is also asserted that WM capacity affects word recognition speed in Arabic (Elmir, 2018); similarly, WM scores explain differences in reading comprehension in Arabic (Elsayyad, 2014).

Conclusions

The data cited above uphold the role of memory in general and WM in particular in academic achievement. it is confirmed that measures of WM correlate deeply with performance in many cognitive tasks such as reading, language comprehension, mathematics. The study of WM repercussion on cognitive tasks dominated other memory structures such as STM and LTM. This can be explained by the fact that STM is considered by some researchers as a substructure of WM like phonological loop; additionally, the development of LTM depends on WM. Moreover, cumulative findings demonstrated that the predictive power of WM for academic performance exceeds Intelligence tests. This leads to the fact that WM becomes in the centre of research that examined the role of memory in cognitive performance. For example, it was confirmed that children with high WM span perform better than children with low WM span; consequently, we can consider WM capacity a reliable predictor of school success**.**

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