THE ROLE OF WORKING MEMORY IN ACADEMIC ACHIEVEMENT

Teo Sieak Ling and Yeo Kee Jiar

shireleneteoh@hotmail.my
kjyeo_utm@yahoo.com

Abstract

Extensive scientific studies in human cognitive psychology have led to further investigation of short term memory with the introduction of working memory. The aim purpose of this conceptual paper is to define working memory and its association with cognitive activities as well as its influence on domain specific activities in academic disciplines.

1.1 INTRODUCTION

Many studies were carried out to investigate factors associated with academic achievements. The influence of working memory on academic learning has drawn extensive attention of psychologists, researchers and educators over the past 25 years. There are findings revealed that a child's success in all aspects of learning is down to how good their working memory is regardless of IQ score (Alloway, 2010). Just only in the first six months of 2007, more than 150 articles on working memory were published in professional journals (Milton, 2008). This amazed figure implies how important of working memory in academic learning. With more knowledge on working memory, educators can better understand how students think, learn and remember. Therefore, appropriate evidence-based interventions can be planned and implemented to help those students with learning difficulties.

1.2 THE MEASUREMENT AND ASSESSMENT OF WORKING MEMORY

According to Baddeley (1986), working memory is "a system for the temporary holding and manipulation of information during the performance of a range of cognitive tasks such as comprehension, learning, and reasoning". Baddeley's model was widely being investigated in a large number of studies over the past 3 decades. Only in 2006, a new model was drawn (see Figure 1).

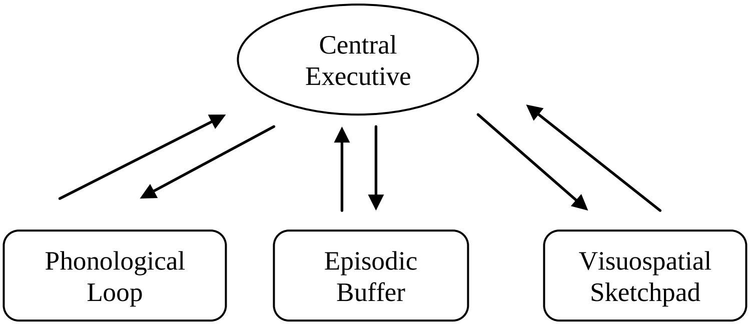

Figure 1 Baddeley's (2006) working memory model.

1.2.1 The Central Executive

The central executive is considered as the core of working memory. It monitors and coordinates the operation of the other three subsystems and relates them to long term memory (Baddeley, 1996a).

However, in the revised working memory, the central executive plays the role in allocating attention (e.g. focusing, dividing and switching attention) within the working memory system.

Complex span tasks are the common measures used to assess the central executive. These tasks require both the processing and storage of information. Complex span tasks are widely used in various studies for instance short-term memory storage and information processing capacity (Daneman & Carpenter, 1980), time-based resource- sharing (Barrouillet et al., 2009), or the mechanisms of working memory capacity (Shipstead et al., 2014).

1.2.2 The Phonological Loop

The phonological loop is a part of working memory that deals with auditory or verbal information (Baddeley & Hitch, 1974). It is divided into two subcomponents: 1) phonological store (inner ear) and 2) articulatory rehearsal process (inner voice).

The phonological store is short-term and holds verbal information (spoken words) for 1-2 seconds before it begins to decay. The articulatory rehearsal process helps to maintain verbal information from the phonological store by reviving the information internally.

To assess the phonological loop functioning, the immediate serial recall of verbal information is commonly used in research. According to Alloway (2006), there are two broad categories of tests to measure verbal memory, namely **verbal short-term memory (STM)** and **verbal working memory (WM)**. Three measures of verbal STM are *digit recall*, *word recall* and *nonword recall*. In such tasks, a sequence of numbers or words is presented, participant is asked to recall the items in their original order.

Participant is considered correct only if an item is recalled in the correct position in the sequence.

As for verbal WM, the three measures are *listening recall, counting recall* and *backwards digit recall.* In such tasks, participant is given verbal information (spoken and written) that require participant to process and manipulate the information before it is be recalled.

1.2.3 The Visuospatial Sketchpad

The visuospatial sketchpad specialises for the maintenance and manipulation of visual and spatial representations (Logie & Baddeley, 2000). It plays a vital role during reading, as it usually encodes printed letter and words while maintaining a visuospatial frame of reference (Baddeley, 1986).

Tasks used to measure the visouspatial sketchpad component of working memory are – **visuospatial STM** and **visuospatial WM**. Three measures of visuospatial STM are *dot matrix, mazes memory* and *block recall.* As for visuospatial WM, it encompasses *odd-one-out, Mr. X* and *spatial span.* All these tasks involve a motor component in the recall aspect of the task. In other words, the participant has to point to the correct spatial locations.

1.2.4 Episodic Buffer

The episodic buffer serves a role for binding information across informational domains and memory subsystems into integrated chunks (Baddeley, 2000). Besides, it has a small storage capacity which does not rely upon the type of input. The capacity of the episodic buffer is not clearly stated, however, it is believed that the more the information can be bound together in a coherent fashion, the greater the capacity of the episodic buffer.

The tasks used to assess episodic buffer component shows heterogeneity in the ways in which that aim might be accomplished (Nobre et al, 2013). No clear methodological agreement exists for assessing the episodic buffer independently (Henry, 2010). Besides, Baddeley (2012) claimed that measurement of the episodic buffer is an unresolved problem.

1.3 WORKING MEMORY AND COMPLEX COGNITIVE SKILLS

Past literature has claimed that working memory is greatly associated with cognitive activities – reading, listening, writing, and solving verbal and spatial reasoning problems. Nevertheless, it should be remarked that the differences between short-term memory and working memory in relation to learning activities. Notably, the later has stronger relationship with academic learning and with high-level cognitive functions (Daneman & Carpenter, 1980).

1.3.1 Working Memory and Literacy

It has been found that working memory is greatly associated with literacy skills such as: reading comprehension, language comprehension, fluency, spelling or writing.

The past literature has proven that verbal STM and WM are consistently found to be related to literacy skill acquisition in children. Children with good phonological memory skills tend to have large vocabulary knowledge than those with poorer memory function.

Table 1 Summary of research on working memory and literacy skills

Authors	n	Years	Components	Literacy Skills
Daneman & Merikle (1996)	6,179	-	Verbal WM	language comprehension
Leclercq & Majerus (2010)	116	4-5	Verbal STM	vocabulary development
Alloway & Alloway (2010)	98	5-6	Verbal STM; Verbal WM	oral reading; reading comprehension; spelling
Berninger et al. (2010)	449	3	Verbal WM	reading; reading comprehension, handwriting, spelling; written
Cain, Oakhill & Bryant (2004)	65	9-11	Verbal WM	reading; reading comprehension

1.3.2 Working Memory and Numeracy

As for numeracy skills, it includes number operations, strategies, number knowledge, and quantity discrimination. However, certain studies have used general skills of Maths as a term in their research with no further explanation.

To predict Mathes competency in children, visuospatial STM and WM play a vital role in it. In certain studies, executive WM is found be important too.

Table 2 Summary of research on working memory and numeracy skills

Authors	n	Years	Components	Numeracy Skills
Alloway & Passolunghi (2011)	206	7-8	Visuospatial WM; Visuospatial STM	addition & substraction; number ranking; number production
Bull, Espy &Wiebe (2008)	124	4-8	Visuospatial STM	maths general skills
Zheng,	310	9-11	Visuospatial	word-problem

Swanson & Marcoulides (2011)			WM; Verbal WM; Executive WM	solving
Krajewski & Schneider (2009)	177	8-9	Visuospatial WM	number quantity competencies

1.4 WORKING MEMORY AND SCHOOL ASSESSMENTS

In 2000, Gathercole and Pickering studied the relationship between working memory and school assessments of a group of 7 year old students. They found students who fell below the standard levels of attainment in English (reading comprehension, and spelling) and Maths tend to have low scores on measure of verbal WM and visuospatial STM. Again, in 2004, this relationship was further explored. The results of younger age group (7-8 year old) showed the verbal STM and verbal WM were highly correlated to both English and Maths. As for older age group, Maths was highly correlated with three WM tasks; listening recall, backward digit recall, and wordlist matching (Gathercole et al., 2004).

St Claire-Thompson and Gathercole (2006) also found verbal and visuospatial WM were highly correlated with attainment in both English and Maths in a sample of 11 year old students.

1.5 CONCLUSION

Both verbal STM and WM abilities play crucial roles in predicting students' (4 – 15 year old) literacy achievement. For younger children, verbal STM appears to be more important as literacy skills are developing. Conversely, visuospatial STM and WM are more important at predicting Maths competency of children. Additionally, some studies also found executive skills (e.g. attention, shifting, and planning) are also related to Maths achievement.

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