

# A Discussion of Working Memory Measurement in Second Language Research

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**Keywords:** Working memory, Working memory measurement, Second language

**Abstract:** Working memory is an crucial cognitive system for language comprehension and production. In second language acquisition research, working memory is always tested through many measuring methods, including simple span tests like digit span test, word span test and nonword span test, and complex span test like reading span test and backward digit span test. These tests are used in many studies and could be modified according to different research situations. From the perspective of the application of working memory tests, with all these different versions of working memory measuring tests, there are still many important issues like the nature, current limitations and the secondary task of working memory span test that need to be concerned.

## 1. Introduction

Working memory is the cognitive system which involves retaining and processing certain task-related information. It is crucial in many important cognitive tasks like language comprehension, making a conversation, memorizing phone numbers, mental arithmetic and solving problems (Baddeley, 2000; Linck et al., 2014).

Working memory is composed of three components: phonological loop, visuospatial sketchpad and central executive. Phonological loop is believed to involve language producing and comprehension, as well as memorizing digits. Visuospatial sketchpad is assumed to store and operate some visual and spatial information. Central executive is supposed to be related with attention management in operating the shortly retained phonological and visual information. Episodic buffer is considered as the component attached to central executive and differs from the central executive in that it is related only with storing temporary information whereas central executive is related with attention control and information processing, including retrieval of information from long-term memory (Baddeley, 2000). These four components together compose the multi-component model, which becomes the most influential and acceptable working memory model to this day.

As discussed above, many studies were carried out to investigate how working memory capacity is related to a wide range of other complex cognitive abilities like mathematical ability and spatial ability. Researchers also found the proficiency of a second language could be affected in some degree by working memory capacity (Papagno, Valentine, & Baddeley, 1991; Walter, 2004). People with higher level of working memory capacity can learn new words more easily, write more skillfully, comprehend texts and listening to materials more proficiently and make conversations more fluently (Linck et al., 2013).

## 2. Working Memory Measuring Tests

Working memory measurement as a whole suggesting the overall working memory functioning ability is divided into two kinds: the tasks that measure the capacity to store and rehearse information (simple span tasks); the tasks that measure the ability to store and rehearse information while operating other cognitive processing tasks (complex span tasks). Research has found out that complex span tasks could predict L1 comprehension better than simple span tasks (Daneman & Merikle, 1996).

## 2.1 Simple Span Test

Simple span test is also known as short term memory test, which is usually measured by recalling sequences of words or digits with different length presented in screen, paper or with voice.

In the case of digit span test, the typical or recommended way to carry it out is through computer software like E-Prime. Through this kind of software, the researchers arrange a first sequence of two digits at a rate of one digit per second presented on screen for the subjects to recall after the first sequence of digits is played. Then, if the subjects recall the first sequence successfully, which they always do, they will continue to recall the next sequence composed of three digits. And next sequence of four digits would proceed if three-digit sequence is recalled successfully. Eventually the subjects would stop at one sequence where they can not recall the presented digits correctly. The number of digit in the sequence where they stopped could be regarded as the capacity of short term memory, which is usually around 7 for most people. The process could also be carried out in aural mode: the subjects are asked to recall the sequences of digit through the researchers' speech instruction and reading aloud, and the subject also need to repeat the digit sequence in voice. In vocal mode, short term memory capacity in second language which concerns more on phonological comprehension could be measured. Thus, in some second language related studies, simple digit span tasks in aural mode are more preferred and recommended.

As for word span test, the process is much alike to that of digit span test, only the digits are replaced by words. The problem is that prior language knowledge would certainly affect the testing result whether it's tested via screen or aural mode. So the testing result would end up with an effect confounded by both short term memory and language proficiency if word span test is employed. One way to lessen the effect is, of course, digit span test in written form, but it still requires some language proficiency.

Another optimal method is nonword repetition test, in which the subjects are asked to listen to audio recordings of new phonetic sequences ranging from simple ones to maximum ones. As each time the audio recording of a sequence is played, the subjects are required to repeat it. The sequence is supposed to be combined with random letters only they conform to certain language phonetics rules. For example, nonwords like "ku-ppy", "ba-ja-pop", "pa-na-fone", "see-koo-da-ja-mint" and "ze-ki-spa-di-tog" are created as English nonword stimuli to measure short term memory in English even they don't make any sense, as long as they apply to phonetic rules in English. As the process continues, the subjects would eventually stop at a sequence where they can't repeat the sequence correctly, which is the point where they scored their short term memory capacity.

## 2.2 Complex Span Tests

As mentioned above, complex working memory tests differs from simple working memory tests in simultaneously measuring both short term memory and other processing activities.

One of the most influential complex working memory tests is reading span test (RST). The RST was originally developed to measure working memory capacity (Daneman & Carpenter, 1980). Later, it was modified by many researchers to measure both working memory and language processing. In a RST, participants are asked to read out a short sentence on a computer screen. Usually a two-sentence sequence is firstly introduced for the participants to read aloud and recall the targeted words in each sentence (the targeted word is usually the last one in a sentence or some underlined one). And the processing part of the test is to judge whether the sentence presented on the screen is grammatical or not, or logical or not. At the end of each testing sequence, the participants are asked to recall as many targeted words as possible. If the participants could recall the targeted words correctly for three times in a five-trial sequence, the test proceeds to the next sequence with three sentences to further recall the targeted words and judge the grammaticality or logicity. And the test stops at the point where the participants fails to recall the targeted words for three times in a five-trial sequence.

Another widely used complex span test is the backward digit span test. In such a test, many aspects and the whole process is just like these in a typical digit span test, except the participants need to recall the presented or played sequence of digits in reverse order.

### **3. The Important Aspects of Working Memory Tests**

There are also many other working memory capacity tests like letter span test, counting span test, letter rotation test, math span test and N-back test, which employed the basic principles in the tests mentioned above. However, with so many modified typical span tests, accurate measurement of working memory still faces some difficulties.

#### **3.1 The Nature of Working Memory Tests**

One critical feature of working memory span tests is to make the participants exert all their strength, namely, use up their working memory capacity. And no other strategies to lessen the task effort and enhance the testing performance should be employed because they are not directly related to working memory capacity and would affect validity and reliability of the test. So the participants need to react to the stimuli immediately and for that to happen there are several examples in the design of the test: the processing sub-test and storing sub-test in the complex tests are both involved; in the RST and operation span test the participants are required to read the presented sentence aloud and proceed to the next sentence immediately, so the the processing task is interfered with the rehearsal task, otherwise, the task would become just a short term memory span test.

#### **3.2 Secondary Tasks in the Span Tests**

The character of secondary task in a complex span test also needs be noticed. The intention of the secondary task is to occupy the attention of the participants, which leaves the participants no time to come up with other strategies. For example, in the reading span test, the grammaticality judgement, logicity judgement, or arithmetic equations are employed. Other modifications are also appropriate as long as it fit the intention of the secondary task. For example, a blank-filling version of RST had been developed to proceed the specific study by Abu-Rabia (2001): according to the meaning the presented sentence tends to convey, participants are asked to fill the blank with the missing word at the end of each sentence instead of memorize the lasted word.

#### **3.3 Current Limitations of Working Memory Span Tests**

Currently, the achievement and scope of working memory related L2 studies is prospering. Yet, looking back over the last several decades, there are still some limitations in this field. Firstly, the participants who take working memory span tests mainly involve undergraduates and graduates; while children and adolescents, whose memory plasticity is relatively much stronger, namely, deserves more attention have been studied less often. Besides, the current measurement of working memory capacity still focuses on behavior experiment. As the development of neuroscience, more advanced techniques like fMRI and ERP, which reflect cognitive activities in human mind more objectively and have been employed in other language learning studies, should be adopted in working memory measurement.

### **4. Summary**

Since the finding of working memory, it has been getting a lot of attention. It is considered to be a very important system for language learning. Based on the related reviews and studies, despite introducing working memory and L2 related literature, this paper mainly discussed several working memory measurements and some critical opinions on them: simple span tests like digit span, word span and non word span measure short term memory capacity only, whereas complex span test like RST and backward span tests measure short memory and processing ability simultaneously by adding extra tasks; the nature secondary tasks in the span tests and limitations of working memory measuring methods are the key issues to proceed working memory related L2 studies.

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