Journal of Applied Linguistics and Language Research
Volume 9, Issue 3, 2022, pp. 1-11
Available online at www.jallr.com
ISSN: 2376-760X

# Korean EFL Children's Working Memory, Vocabulary, and Reading Comprehension: A Path Analysis Approach

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**Abstract**
This study aims to investigate the relationships among working memory, vocabulary acquisition, and reading comprehension for young English as a Foreign Language (EFL) learners in South Korea. To identify children's working memory, receptive vocabulary knowledge, and reading comprehension skills, the conceptual span task, picture vocabulary size test, and STAR reading test were conducted with 88 children. The results of this study are as follows. First, the influence of vocabulary acquisition on reading comprehension was found to be significant. Second, working memory had a direct effect on vocabulary acquisition but not on reading comprehension. These results imply that working memory should be considered as one of the several factors that can influence vocabulary acquisition. Furthermore, it is necessary to reduce the working memory requirement to prevent learners' memories from being overloaded.
**Keywords:** young learners, working memory, vocabulary acquisition, reading comprehension

## INTRODUCTION

It has been wondered whether students who are in the same environment acquire L2 differently. L2 researchers have tried to investigate the factors of individual differences in L2 learning. One of the spotlight factors is memory capacity and, especially, working memory, which is one of the most extensively investigated factors relating to individual differences in cognition (Martin & Ellis, 2012). Many studies conducted until now highlight the positive relationship between working memory and vocabulary. According to Gathercole and Baddeley (1993), the working memory of both children with and without language disorders has a positive relationship with vocabulary acquisition. In an ESL situation, Jung and Choi (2012) reviewed the correlation between working memory capacity and vocabulary acquisition. The group of elementary students with high working memory acquired more than double vocabulary than the group with low working memory. In terms of the relationship between working memory and reading comprehension, Cain, Oakhill, and Bryant (2004) insist that children's working memory is related to reading comprehension; however, phonological decoding and vocabulary are the main predictors of reading comprehension according to Seigneuric and Ehrlich (2005), who discovered that working memory is not a predictor of reading

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comprehension for young learners. Controversy exists on the correlation between working memory and reading comprehension, but many studies have proven a concrete causal mechanism between vocabulary and reading comprehension skills.

Although working memory is a critical factor to explain individual differences in L2 learning, the relationship between working memory and language acquisition has been mainly investigated among L1 learners, disordered children, or L2 adult learners, while research on the relationship between working memory and L2 acquisition for L2 young learners is lacking. Considering the current trend of beginning English language acquisition from a young age, it is necessary to conduct research on L2 young learners; thus, I examined the relationship among the working memory, vocabulary, and reading comprehension. This study's research questions are as follows:

1) Does working memory influence vocabulary knowledge?

2) Does vocabulary knowledge mediate between working memory and reading comprehension?

## PREVIOUS STUDIES

### Working memory and measurement

According to Baddeley (2003), working memory is defined as a human cognitive system that processes and stores information temporarily due to limited capacity. Working memory is the ability to process information consciously, concentrating on that information and making decisions by illuminating and focusing on a mental spotlight (Alloway & Alloway, 2014). In other words, it refers to the cognitive system responsible for the control, regulation, and active maintenance of information in the face of distracting information (Conway, Jarrold, Kane, Miyake, & Towse, 2007). Thus, working memory acts as a mechanism involved in ensuring that information is used appropriately and transferring new information to long-term memory. Individual differences in working memory ability lead to differences in the task performance in school classes, which require memorizing many pieces of information and paying attention to teachers' instructions (Lee & Kang, 2021).

Working memory is distinguished from short-term memory in that it includes the storage of temporary information and the processing of information. A variety of measuring tools exist to measure this working memory ability. Simple tasks that measure only storage components include word span task and digit span task, and complex tasks that measure both storage and processing components include counting span task, reading span task, listening span task, and conceptual span task (Nowbakht, 2019).

Working memory is an important factor of the cognitive processes underlying bilingual language processing and performance on measures of L2 proficiency. Over the years, researchers have been studying the effects of working memory on L2 learning. According to Martin and Ellis (2012), working memory is correlated with vocabulary learning for university monolingual students. In addition, Hazrat (2015) reveals the relation between productive and receptive vocabulary knowledge with working memory capacity for English teachers in Iranian. For bilingual children, Cockcroft (2016) determined that working memory is significantly associated with vocabulary. However, most studies on working memory and vocabulary have focused on L1 learners, and even though vocabulary learning is crucial for L2 acquisition, few studies have been conducted about it.

## The relation among working memory, vocabulary, and reading comprehension

Many researchers have revealed the importance of vocabulary knowledge for reading comprehension (Hulstijn, 2001; Lee, 2018; Poctor, Carlo, August & Snow, 2005), showing that vocabulary is a major factor in it.

The studies that have revealed the relationship between working memory and vocabulary learning are the following. According to Chrysochoou, Bablekou, Masoura, and Tsigilis (2013), who targeted young learners, verbal working memory was found to be related to vocabulary learning. Similarly, Ibarra Santacruz and Martínez Ortega (2018), who studied university students, discovered that working memory helps minimize the learner's memory limitation and aids their vocabulary memory. In addition, Hazrat (2015), who studied adults taking teacher-training courses, found a positive correlation between working memory and vocabulary learning. Accordingly, most previous studies found a relationship between working memory and vocabulary learning.

The following are previous studies that have investigated the relationship between working memory and reading comprehension. Chang, Wang, Cai, and Wang (2019), who studied middle school students, found that students with higher reading span performed better in reading comprehension. Moreover, in a study by Varol and Erçetin (2016) targeting adults, learners with the higher backward digit span had higher reading comprehension scores. The same result was found in a study by Nowbakht (2019) on students attending language institutes.

On the contrary, Joh and Plakans (2017) insist that reading comprehension ability is determined by the knowledge of most L2 languages, even though the learner has a considerable amount of working memory capacity. Oh (2011) argues that vocabulary acquisition is more direct as a major predictor of reading comprehension than working memory in the early stage of language acquisition. These previous studies suggest that the impact of working memory on reading comprehension may vary depending on the learner's level and age. Although working memory is a major concept in learning, it is difficult to find studies that target children learning English. In addition, since few existing studies focus on the relationship between the three constructs of working memory, vocabulary acquisition, and reading comprehension, this study intends to examine this relationship for children learning English.

## METHOD

### Participants

Eighty-eight children aged 7 years were recruited from a private English language institute located in South Korea. They were all native speakers of Korean, and none of them had any known cognitive or sensory impairment.

## Measures and data collection

For assessing children's working memory and receptive vocabulary knowledge appropriate for the purpose of this study, a pilot study was conducted with 25 children aged 7 years. Since the Situation, Task, Approach, and Results (STAR) reading test had been administered once a month, it was not conducted during the pilot study. Conceptual span tasks, receptive vocabulary test, and STAR reading test were administered for one week, with each test being conducted on a different day of the week for approximately 25 minutes.

### *Conceptual Span Task (CPT)*

The conceptual span task was conducted to measure children's working memory. It was developed by Haarmann, Davelaar, and Usher (2003), and it involves repeatedly looking at a series of words presented by category and recalling only words from a specific category. It is designed to orient the subjects' maintenance and retrieval processes toward stimulus meaning (Kane & Miyake, 2007). In this study, tests were conducted in Korean to ensure that differences in English language skills did not affect working memory measurements. All students simultaneously participated in the test, and the questions were presented through video as PowerPoint data; students were instructed to write answers on their answer sheets. Figure 1 below shows an example of conceptual span task items presented as PowerPoint data.

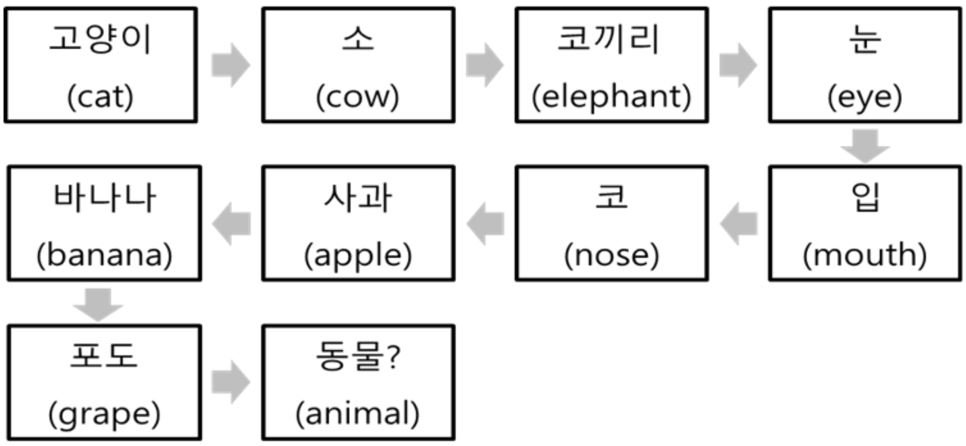


**Figure 1.** An example of conceptual span task

In the example above, the task present lists of nine randomly ordered words that belonged to three different semantic categories, and children are asked to write the words related to one semantic category on their answer sheet. The answers to the example questions above are cat, cow, and elephant. The test consists of six questions, and a total of 18 points (six questions * three words) can be obtained by accurately recalling all words. Pictures were presented because the learners were not yet familiar with the written form of words.

## *Picture Vocabulary Size Test (PVST)*

The Picture Vocabulary Size Test (PVST), which was developed by Anthony and Nation (2017), was used to measure children's receptive vocabulary knowledge. It measures whether students can find a suitable meaning (a picture) for a given partly contextualized word form. The experiment presented by Anthony and Nation (2017) included two 96-item test sets. However, in this study, 20 questions were modified and supplemented to account for environmental constraints and learners' level. Figure 2 below shows a sample question for the PVST.


**Figure 2.** A sample question for the PVST

When a teacher reads the word and sentence aloud, students mark the corresponding word on the answer sheet. If all questions are answered correctly, a total of 20 points are given.

## *STAR reading test*

The STAR reading test was administered to measure children's reading level. It was developed by Renaissance Learning, and it is designed to gauge the reading comprehension skills and ability of students in grades 1–12. It is computer-adaptive test and provides teachers with immediate feedback on each student's reading development. The questions in this test cover 46 reading skill areas spread across five domains that include analyzing literary text, word skills and knowledge, analyzing argument and evaluating text, comprehension strategies and constructing meaning, and understanding the author's craft. This assessment tests a student's skills in real-time, constantly adjusting the difficulty depending on a child's earlier responses. Based on the results of this computer-adaptive test, a scaled score is computed.

## Data analysis

The internal consistency of the tests was checked using Cronbach's alpha; the results were 0.687 and 0.586, respectively for conceptual span tasks and receptive vocabulary size test. This study was subject to the following analytical processes. First, correlation analysis was conducted to identify the extent of relationships among working memory, receptive vocabulary size, and reading comprehension. Second, path analysis was conducted using AMOS 22 to test the initial model that was hypothesized based on relevant studies (see Figure 3).

# RESULTS

## Descriptive Statistics and Correlations

Table 1 shows descriptive statistics for working memory, vocabulary size, and reading comprehension.

**Table 1.** Descriptive statistics

| | ***N*** | ***M*** | ***SD*** | **Min** | **Max** |
|---|---|---|---|---|---|
| Working Memory | 88 | 14.47 | 2.72 | 7.00 | 18.00 |
| Vocabulary Size | 88 | 12.15 | 2.63 | 4.00 | 18.00 |
| Reading Comprehension | 88 | 1.89 | .58 | 1.00 | 5.10 |

The mean score of working memory measured by the CPT was 14.47, and the mean score of receptive vocabulary size measured by the PVST was 12.15. Lastly, the mean score of reading comprehension measured by the STAR reading test was 1.89.

A correlation analysis was conducted to examine the relationship between working memory, receptive vocabulary size, and reading comprehension (see Table 2).

**Table 2.** Correlation matrix

| | **Working memory** | **Vocabulary size** | **Reading comprehension** |
|---|---|---|---|
| Working memory | 1 | .322** | .144 |
| Vocabulary size | .322** | 1 | .378** |
| Reading comprehension | .144 | .378** | 1 |

$^*p < .05$, $^{**}p < .001$

As can be seen, working memory was significantly correlated with vocabulary size ($r$ = 0.322, $p < 0.01$); however, it did not correlate with reading comprehension. The correlation between vocabulary size and reading comprehension was also found to be significant. Overall, these results indicate significant relationships between working memory and vocabulary size and between vocabulary size and reading comprehension.

## Path Analysis

A path analysis was conducted to identify the best model fit among the three variables (see Figure 3). The model with the best fit was investigated based on seven types of fit statistics: CMIN/DF (below 3.0), RMR (below 0.5), GFI (over 0.9), AGFI (over 0.9), CFI (over 0.9), NFI (over 0.9), and RMSEA (below 1.0).

The initial goodness of fit for Figure 3 was CMIN/DF = .000, RMR = .000, GFI = 1.000, AGFI = .697, CFI = 1.000, NFI = 1.000, and RMSEA = .000. Except for the score of AGFI, the scores were all found to be reasonable for accepting the model.

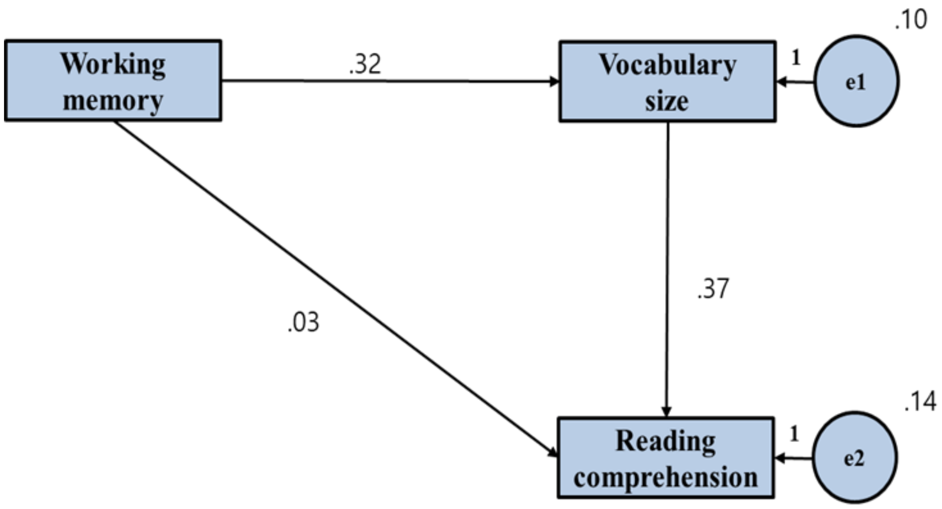


**Figure 3.** Initial model

Table 3 shows the analysis of the causal relationships in the initial model. The table indicates that the influence of working memory on reading comprehension was not significant, and therefore, the path was deleted.

**Table 3.** Parameter estimation and tests for statistical significance for the initial model

| Path | Unstandardized coefficient | Standardized coefficient | S.E. | C.R. |
|---|---|---|---|---|
| Working memory → Vocabulary size | .312 | .322* | .098 | 3.177 |
| Vocabulary size → Reading comprehension | .081 | .370** | .023 | 3.534 |
| Working memory → Reading comprehension | .005 | .025 | .022 | .239 |

*$p < .05$, **$p < .001$

The final goodness of fit of Figure 4 was CMIN/DF = .057, RMR = .014, GFI = 1.000, AGFI = .997, CFI = 1.000, NFI = .998, RMSEA = .000. The scores were all found to be reasonable for accepting the measurement model. The results of the causal relationships indicated statistically meaningful influences in all paths, as shown in Table 4.

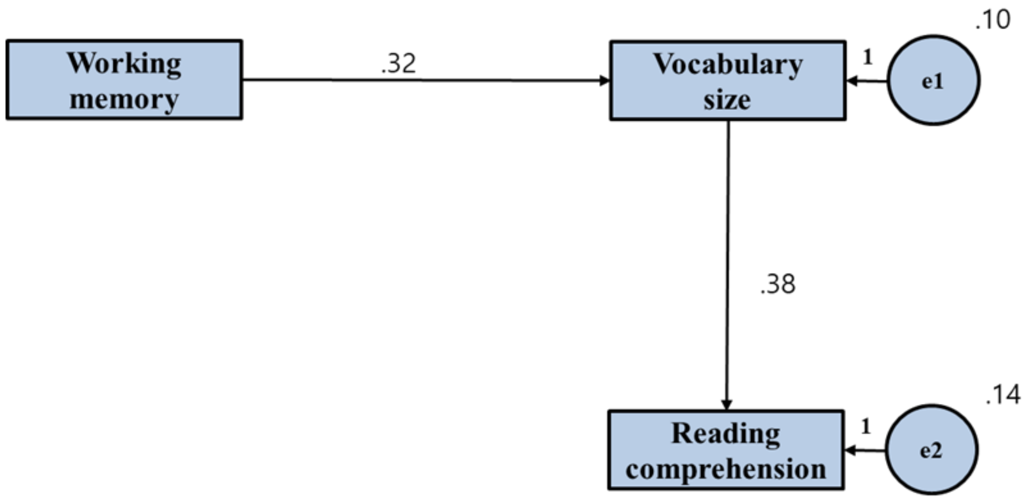


**Figure 4.** Final model

**Table 4.** Parameter estimation and tests for statistical significance for the final model

| Path | Unstandardized coefficient | Standardized coefficient | S.E. | C.R. |
|---|---|---|---|---|
| Working memory → Vocabulary size | .312 | .322* | .098 | 3.177 |
| Vocabulary size → Reading comprehension | .083 | .378** | .022 | 3.813 |

* $p < .05$, ** $p < .001$

The influence of working memory on vocabulary size was 3.177 ($p = .001$), which was statistically meaningful at the 99% confidence level; this indicates that higher working memory leads to higher vocabulary size. The influence of vocabulary size on reading comprehension was 3.913 ($p = .000$), which was statistically meaningful.

**Table 5.** Decomposition of standardized effects for final model.

| Path | | Working memory | Reading comprehension |
|---|---|---|---|
| Vocabulary size | Direct effect | .322 | .378 |
| | Indirect effect | .000 | .000 |
| | Total effect | .322 | .378 |

Table 5 reports the decomposition of standardized effects for the final model. The standardized total effects are gained by adding indirect and direct effects; for example, the total effect of working memory on vocabulary size is calculated as follows: direct effect (.322) + indirect effect (.000).

## DISCUSSION

The present study sought to examine the relationship among working memory, receptive vocabulary size, and reading comprehension for young EFL learners in South Korea. As a result, the influence of working memory on vocabulary was found to be significant, while it was not found to be significant on reading comprehension. The influence of vocabulary size on reading comprehension was also found to be significant.

This finding regarding the relationship between working memory and vocabulary size supports the view that working memory influences vocabulary size for EFL young learners - a result that has been already found in previous studies of L1 and L2 learners (Chrysochoou et al., 2013; Jung & Choi, 2012). These findings also support the study by Ibarra Santacruz and Martinez Ortega (2018), in which working memory training helps minimize the learner's memory limitations and aids their vocabulary memory.

The finding on the relationship between working memory and reading comprehension parallels those of Seigneuric and Ehrlich (2005) and Martin and Ellis (2012), who reported that working memory fails to account for the reading comprehension of native English speakers and that vocabulary size is significantly related to working memory. These research results support the findings of Oh (2011) and Lee (2014), according to whom vocabulary acquisition is a direct major predictor of reading comprehension compared to working memory for a group with high proficiency or learners at the beginning stage of language acquisition. However, the finding does not support previous studies by Nowbakht (2019) and Chang et al. (2019), which found working memory to be a significant predictor of reading comprehension. These divergent results show that the relationship between working memory and reading comprehension might be affected by working memory tasks. According to Seigneuric, Ehrlich, Oakhill, and Yuill (2000), children's verbal and numerical working memories are both related to reading comprehension. Conversely, children's performance in working memory tasks that require the manipulation of shapes and patterns does not explain variance in reading comprehension. The CST for young learners used in this study were implemented not with words but with pictures; therefore, the result that shows a relationship between working memory and reading comprehension aligns with the findings of Seigneuric et al. (2000).

The results of this study indicate that working memory should be considered as one of the several factors that can influence vocabulary size. This supports previous studies on the positive relationship between vocabulary size and reading comprehension. Based on these findings, teachers must be aware that students' working memory plays a significant role in learners' vocabulary acquisition. As proposed by Lim and Seo (2016), this study also suggests that it is necessary to reduce the working memory requirement, so that the learner's memory is not overloaded, and to help them utilize various vocabulary learning strategies.

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