

# Exploring Working Memory Capacity as an Independent Contributor to L2 Discourse Comprehension: A Study of Korean EFL Learners<sup>\*</sup>

Jeongsoon Joh  
(Konkuk University)

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The purpose of the present study was to investigate whether and how working memory capacity contributes to discourse comprehension in L2. Participants were 60 Korean college students of various academic backgrounds, and their working memory capacity was measured by a reading span task in L1 and L2. Their L2 knowledge and background knowledge were also measured to examine the relative contribution of working memory capacity to L2 reading. Major findings include the following: there was more overlap between L1 and L2 working memory capacity than between L2 working memory capacity and L2 knowledge, suggesting L2 working memory capacity would be more of memory capacity itself than of L2 knowledge; only composite working memory capacity significantly predicted L2 discourse comprehension, but not storage or processing component alone; composite working memory capacity proved to be an independent contributor to L2 discourse comprehension, though less powerful than knowledge variables.

**Keywords:** working memory, storage, processing, composite capacity, L2 reading, discourse comprehension

## 1. Introduction

The general agreement about a close association between one's ability to read with understanding and his/her academic achievement has kept motivating researchers to explore the cognitive processes and/or factors that would distinguish good readers from poor ones. Out of a variety

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of cognitive skills and processes required for successful reading comprehension, memory capacity (especially what is called working memory) has been one of the major research interests among psycholinguists, as an important predictor of one's reading comprehension ability since Daneman and Carpenter's (1980) classic study. Many of previous studies, mostly with L1 readers as participants, highlighted the role of working memory in reading comprehension, observing that it is necessary in integrating existing and newly incoming information, and in constructing textual meaning by inferring the relationship between the old and new information.

Despite the overall consensus about the importance of working memory in comprehension, there have also been occasional disputes about its exact nature as a possible explanation of individual difference in reading comprehension. While some researchers claimed that working memory capacity adequately explains individual difference in comprehension as it better predicts reading comprehension performance than verbal ability (e.g., Seigneuric, Ehrlich, Oakhill, & Yuill 2000), others maintained that even those with enough working memory capacity could have difficulty in comprehending (e.g., Perfetti, Marron, & Foltz 1996). Another controversy concerns whether working memory capacity contributes to reading comprehension uniquely and independently of other predictors such as vocabulary knowledge, and word recognition and decoding (e.g., Swanson & Berniger 1995; Yuill, Oakhill, & Parkin 1989), or it explains to a considerable degree the same variance as those other factors (e.g., Nation, Adams, Bowyer-Crane, & Snowling 1999; Stothard & Hulme 1992).

Meanwhile, L2 reading researchers have paid attention to target language proficiency, background knowledge, interest or motivation, and strategy use as the factors that could contribute to readers' comprehension performance in L2. However, not much research has been conducted about the role of working memory in the context of L2 reading, which sharply contrasts with a plethora of studies conducted in Europe and North America in L1 setting. It is only since 1990's that studies of working memory in the context of L2 reading have begun to be published in major academic journals, and much fewer research reports are found in Korea

about this issue.

Although previous studies conducted in L1 setting have generally found a significant contribution of working memory capacity to reading comprehension either independently or together with other variables, it is not certain whether it would play a similar role in L2 reading, not only because of the difference between L1 and L2 reading but also because of the relative scarcity of relevant studies. In one of the earliest studies of working memory in the context of L2 reading, Harrington and Sawyer (1992) examined whether working memory could predict reading skills in L2 as well as in L1 reading, and found that only the performance in a sentence span task (but not either word span or digit span task) showed a moderate correlation with a measure of L2 reading comprehension. Although they allegedly confirmed the usefulness (or validity) of the sentence span task as a reliable measure of working memory in L2 reading context, many important questions remained unanswered, as they admitted.

Since then, more studies of working memory have been conducted in L2 reading context (e.g., Alptekin & Erçetin 2009, 2010, 2011, 2013; Juffs 2005; Leaser 2007; Payne, Kalibatseva, & Jungers 2009; Rai, Lester, Harris, Peck, & Cook 2011; Swanson, Orosco, Lussier, Gerber, & Guzman-Orth 2011; Walter 2004) and succeeded to a considerable degree in figuring out the role of working memory in L2 reading comprehension. However, the findings are somewhat mixed, still requiring for more rigorous and extended studies of the relevant issues. For example, some researchers found that L2 working memory uniquely and independently contributed to L2 reading (e.g., Alptekin & Erçetin 2009, 2010, 2011, 2013; Payne et al. 2009; Swanson et al. 2011), while others did not (e.g., Juffs 2005; Leaser 2007; Rai et al. 2011). Another point of interest concerns the transferability of working memory capacity from L1 to L2. Actually some researchers found out that L1 and L2 reading span showed quite a high correlation (Osaka & Osaka 1992; Service, Simola, Metsanheimo, & Maury 2002), implying a possibility that one's working memory capacity might be stable across languages. But more empirical studies would be necessary to generalize whether or not one's memory capacity stably contributes to reading comprehension regardless of the language s/he is reading in.

Quite recently, several researchers explored the role of working memory in the context of Korean EFL learning (Baek 2013; Choe 2011; Lee 2014a, 2014b). All these researchers claimed a positive contribution of working memory to L2 comprehension, but they diverged in how it does. For example, while S Baek (2013) found that the processing component of working memory largely co-varied with target language proficiency, failing to independently predict comprehension ability, J-H Lee (2014a, 2014b) found out its independent contribution. These previous studies in Korean EFL context, however, are all confined to sentence-level comprehension in examining the predictive power of working memory capacity.

As can be seen in the review of literature, previous studies of working memory in the context of L2 reading still have niches to fill in, and the exploration of working memory as a possible factor of L2 reading among Korean EFL learners is far from sufficient with its relatively short history and restricted scope of investigation. Therefore it seems necessary to empirically examine whether one's working memory capacity is a substantial predictor of reading comprehension among L2 readers in general, and among Korean English learners in particular, as claimed in previous researches in L1 setting. Also of importance is to figure out the relationship between working memory capacity and other well-known factors in L2 reading such as target language proficiency, background knowledge, topic familiarity, or strategy use.

Motivated by this realization of *status quo* of working memory studies in L2 reading context, the present study aims to conduct a more rigorous and finely-tuned study to elucidate the role of working memory by involving Korean EFL learners. More specifically, this study intends to figure out whether and how working memory contributes to L2 reading comprehension at discourse level, trying to answer some of the questions not yet fully answered, such as the relationship between L1 and L2 working memory, that between L2 working memory and L2 proficiency, and the relative contribution of working memory compared to other factors involved in reading comprehension.

## **2. Review of Literature**

### **2.1. The Role of Working Memory in Comprehension**

The reason for individual difference in reading ability has long interested many researchers. Schema (e.g., Anderson & Pearson 1984), word knowledge or word reading skills (e.g., Perfetti 1985; Stanovich, Cunningham, & Feeman 1984), and higher-level processes of language understanding such as inferring or integration of information (e.g., Daneman 1991; Hannon & Daneman 1998; Long, Oppy, & Seely 1994) have been mentioned as major sources of individual difference in reading skills. Meanwhile, since the introduction of the concept of ‘working memory’ as a pre-requisite in the process of such higher-level understanding, working memory began to be perceived as a useful predictor of comprehension ability, especially among psycholinguists (e.g., Baddeley, Logie, Nimmo-Smith, & Brereton 1985; Cain, Oakhill, & Bryant 2004; Daneman & Merikle 1996; Just & Carpenter 1992). In a historical study of the role of working memory in reading, Daneman and Carpenter (1980) described working memory as having both processing and storage functions, “a more active part of the human processing system (p. 450)”, while traditionally conceived short-term memory concerned simply passive storage. It is believed that working memory makes possible the integration of propositions, which is necessary for establishing textual coherence; it also keeps the information retrieved from one’s long-term memory enabling the retrieved information to be integrated with the currently active text (Cain et al. 2004).

Since the early 1980’s, many studies tried to figure out the relationship between working memory capacity and text comprehension, and a positive correlation was found between working memory and specific reading skills such as finding out referents of pronouns, remembering factual information, and inferring the meaning of words from context (e.g., Daneman & Green 1986; Masson & Miller 1983). In studies involving children, the performance in a working memory task that required processing and storing words, sentences, and numbers was found positively correlated with reading comprehension (de Beni, Palladino, Pazzaglia, &

Cornoldi 1998; Seigneuric et al. 2000; Stothard & Hulme 1992). Based on these findings a tentative conclusion was drawn that working memory could play an important role independently of other predictors of reading ability such as decoding skills, word recognition skills, or word knowledge. However, there arose a need for more research on the relationship between working memory and general language skills, since it was found that children's word knowledge and verbal intelligence also predicted their reading ability (Oakhill, Cain, & Bryant 2003; Sternberg & Powell 1983), and that word knowledge also affected the performance in the measure of working memory among adults (Dixon, LeFevre, & Twilley 1988).

## 2.2. Working Memory in L2 Reading

In one of the earliest study of working memory in L2 context, Harrington and Sawyer (1992) testified whether working memory could predict L2 reading skills as well as in L1 reading, using three different measures of working memory (word span, digit span, sentence span). Finding out a moderate correlation between the sentence span and the measure of L2 reading comprehension, they suggested further studies to answer the questions they could not answer such as exactly which processes of L2 reading are affected by working memory capacity, whether or not one's working memory capacity in L1 transfers to L2, and whether working memory capacity in L2 grows as L2 proficiency develops. Also it was not clear how much of L2 reading could be explained by working memory capacity, i.e., the relative contribution of working memory to L2 reading comprehension compared to other factors, and whether it is comparable to that in L1.

A series of recent study by Alptekin and Erçetin (2019, 2010, 2011, 2013) attempted to investigate multi-dimensionally the role of working memory in L2 reading. They employed two different tasks of working memory (i.e., recognition task and recall task), divided reading comprehension into two subcategories (i.e., literal understanding and inferential understanding), and investigated the relationship between L2 reading and working memory. Results indicated that composite scores of the working

memory measure better correlated with inferential understanding than with literal understanding (Alptekin & Erçetin 2009). They also found that there was a positive correlation between L1 and L2 processing capacity, and between L1 and L2 storage capacity, but that only L2 working memory significantly correlated with inferential understanding in L2 (Alptekin & Erçetin 2010). Further, they included background knowledge (operationalized in their study as content familiarity) along with working memory as potential factors in L2 reading, and reported that these two factors independently contributed to inferential understanding, but not to literal understanding, among advanced level Turkish learners of English (Alptekin & Erçetin 2011).

Similarly, Leeser (2007) also included topic familiarity as an additional variable in a study with beginning level learners of Spanish, and found that it was topic familiarity, not working memory, which consistently influenced reading comprehension, and that the effect of working memory depended on topic familiarity. This finding contrasts with Alptekin and Erçetin (2011) that found out an independent contribution of both working memory and topic familiarity, suggesting a need for more research involving L2 learners from a variety of backgrounds. Such discrepancy in result might be attributed to the difference in L2 proficiency level of the participants (i.e., advanced level learners in Alptekin and Erçetin, and beginning level ones in Leeser). However, Swanson et al. (2011), where low-proficiency ESL children participated, found out a unique contribution of working memory to L2 reading, complicating the picture and requesting more empirical studies to validate such reasoning.

By contrast, Payne et al. (2009) concluded that working memory has an independent influence in L2 reading regardless of L1 reading skills, background knowledge, or previous experience in L2 reading. In a similar vein, Walter (2004) found, in a study of French learners of English, that higher level L2 learners, unlike lower level ones, successfully transferred their L1 reading skills to L2, and that they also showed better working memory in L2. This means even good L1 readers might not read well in L2 if they have deficiency in working memory capacity, suggesting that L2 working memory capacity could better predict L2 reading ability

than L1 reading skills do. Such result contrasts with several studies which showed skepticism about an independent contribution of working memory to L2 reading. Meanwhile, in a study with intermediate level Spanish learners, Rai et al. (2011) observed that the role of working memory in L2 reading could vary as a function of task characteristics, strategy use, or even the degree of stress. This study deserves attention as it implies the complicated mechanism by which working memory plays a role in L2 reading, possibly more complicated than in L1 reading.

Meanwhile, it is only very recently that researchers began to examine the role of working memory in the context of Korean EFL learning. M-H Choe (2011) used two measures of memory capacity (word span and sentence span) and two language processing tasks (sentence-repeating and answering comprehension questions) in order to investigate the relationship between working memory capacity and sentence processing ability, finding out that only sentence span correlated with processing tasks, especially with the comprehension task. S Baek (2013) found out that the processing component of working memory capacity highly overlapped with English proficiency. According to him, only storage component uniquely predicted sentence comprehension ability although both the processing and storage components correlated with comprehension of relative clauses. Contrasted with this finding is J-H Lee's (2014a, 2014b) studies, where a significant and moderate correlation between the processing component and English listening comprehension was found, which was higher than the correlation between listening comprehension and English proficiency or storage component. It is not certain at the present, though, whether such difference in findings is associated with different language modules (i.e., reading vs. listening) in the studies being compared. J-H Lee (2014b) also found that working memory capacity was significantly correlated only with listening comprehension but not with grammaticality judgment, observing task-specific nature of the relationship between working memory and comprehension. Correlational analyses, however, could have limitations in determining the unique and independent contribution of a specific variable to comprehension ability.

### 2.3. Summary and the Orientation of the Present Study

From the review of previous working memory studies in L2 reading context, several areas of further research emerged as follows, which motivated the current study. First, existing studies have disparities in their operationalization of L2 reading comprehension: e.g., recall protocols in Leiser (2007); inferential processing or reasoning in Rai et al. (2011) and Miller, Cohen, and Wingfield (2006); literal and inferential understanding in Alptekin and Erçetin (2009). For this reason, the present study uses a measure of L2 reading comprehension that includes a wide variety of component skills of reading, for the purpose of enhancing the validity of findings. Second, many of the previous studies tend to be limited in elucidating the relative contribution of working memory as they did not simultaneously consider other variables associable with L2 reading. Therefore, the present study attempts to rigorously examine the independent and relative contribution of working memory capacity to L2 reading, if any, by including other relevant factors such as target language proficiency and background knowledge.

In addition, as one of the controversies about the role of working memory in L2 reading concerns its relationship with L2 proficiency and/or working memory in L1 (i.e., whether it is more of memory capacity *per se*, or it varies with L2 proficiency), the present study closely examines the interrelationships among L1 and L2 working memory and L2 proficiency, and then systematically partials out such relationships in determining exactly how working memory capacity intervenes in L2 reading comprehension process.

Another problem pertains to the measure of working memory. Previous studies usually employed a reading span task, but different aspects of reading span were used as the criterion in different studies. For example, some researchers used the storage component only while others considered both storage and processing components. Also, different ways of measuring the processing component were used in different studies (e.g., a grammaticality judgment task, a sensibility judgment task, or comprehension check-up questions). Such diversity in measures could lead to difficulty

in comparing and interpreting the findings. In an effort to solve such a problem, the present study counted both separate (i.e., storage and processing capacity respectively) and composite aspects (i.e., storage and processing capacity combined) of working memory, and then examine whether there is difference in results attributable to different aspects of working memory capacity.

Finally, although there are several recent studies in Korea on the role of working memory in L2 comprehension, little empirical research has been conducted at discourse level. There is also a need for a more precise approach to inferential statistics in order to delineate the complicated relationships among variables involved in reading comprehension. The current study is an attempt to answer some of the questions not fully answered about the role of working memory capacity in L2 discourse comprehension, by inviting Korean EFL learners as participants.

Based on the review of previous studies and within the scope and purposes of the current study, the following research questions were posed: (1) Does L1 working memory capacity transfer to L2? (i.e., What is the relationship between L1 working memory and L2 working memory?); (2) Does L2 working memory co-vary with L2 proficiency? (i.e., What is the relationship between L2 proficiency and L2 working memory?); (3) Does L2 working memory independently contribute to L2 discourse comprehension? If so, how much is the relative contribution of working memory?

### **3. Method**

#### **3.1. Participants**

Sixty Korean college EFL learners participated in this study. They were from diverse academic backgrounds, including education, liberal arts, economics, animal science, engineering, statistics, and so on. Twenty seven were male and 33 were female, and their mean age was 21.6. Their English proficiency level was roughly estimated as ranging from high intermediate to advanced, based on their scores on the English subpart of KSAT or

standardized tests of English proficiency such as TOEFL and TOEIC (ranging from 55 to 100 with the mean of 90.54 and SD of 9.26).<sup>1)</sup>

### 3.2. Instruments

#### 3.2.1. Measure of Working Memory: Reading Span Task

A reading span task was used to assess the participants' memory capacity in L1 and L2. Previous studies have proved the reading span task consistently to be a more useful tool than either word span or digit span task in exploring the role of working memory in reading (e.g., Cain et al. 2004; Hannon & Daneman 2001; Harrington & Sawyer 1992). The task was constructed using E-prime to be administered on-line with individual participants.

The task was comprised of a total of 60 sentences each in the participants' L1 and L2 (statements in form, and 8 to 13 words in length). The decision on the length and syntactic/semantic difficulty level of the sentences was made by referring to previous studies quoted earlier in this paper. There were three sets of sentences at each level, where the 'level' was defined as the number of sentences in a given set. For example, the participants would read three sets of 4 sentences (12 sentences total) at Level 4. The maximum number of sentences in a set (i.e., the highest level) was 6 in this study. The sentence-final word was all different across the 60 sentences, and all the sentence-final words in a set began with different sounds. The English sentences were extracted from the English textbooks (including workbooks and activity books) for Korean 10th graders, and the Korean sentences, from secondary school textbooks for such subjects as Korean and social studies, both of which were written under the guidelines of Korean national curriculum.

In the literature, different researchers differently operationalized working memory capacity in their pursuit of its role in comprehension: e.g., the number of the sentence final words correctly recalled (i.e., storage component) either without assessing processing component itself, or with-

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1) For the sake of comparison across different score systems, all the scores were transfigured into percentage rate, where the highest possible score is 100.

out considering the processing component in the analysis even though it was part of the task (e.g., Cain et al. 2004; Daneman & Carpenter 1980); the number of correctly recalled sentence-final words only in the sets where the participant correctly answered a comprehension question in the given set (e.g., Swanson 2013; Swanson & Ashbaker 2000). Considering these disparities in the literature, the present study chose to put into analysis all three aspects of working memory capacity, i.e., processing component, storage component, and the composite of these two, for the sake of comparisons across different components in light of the role of working memory capacity in L2 reading on one hand, and for the purpose of comparing the finding from the present study with those from previous studies that differently operationalized working memory capacity, on the other hand.

Accordingly, the reading span task for the present study was designed to elicit these three related but potentially different components of working memory capacity. While storage capacity was gleaned by asking the participants to recall the last words of the sentences they read in a given set, processing capacity was assessed by asking the participants to answer a question about one of the sentences in the set. This was an experimental device to prevent the participants from paying their attention only to the final words without trying to understand the sentences. Other devices used in previous studies for the same purpose include judging the sensibility, truth value, or grammaticality of sentences (e.g., Baddely et al. 1985; Daneman & Carpenter 1980; Hannon & Daneman 2001; Harrington & Sawyer 1992; Miller et al. 2006; Turner & Engle 1989). The present study chose to use comprehension check-up questions as a measure of processing component since it seemed more natural for a reader to read a normal sentence both in grammar and semantics and then to be asked to recall a specific part of the sentence while, at the same time, showing an evidence that s/he has understood what the sentence is about. The location of the sentence in a given set about which a question was made, and the position in a given sentence where the expected answer (or a clue for it) was situated were carefully varied across sets and levels in order to avoid any possible threats to the validity of the task. Lastly,

the composite capacity was determined by the number of the correctly recalled sentence-final words only in the sets where the comprehension question was correctly answered.

### 3.2.2. Measure of L2 Reading Comprehension

In order to measure the participants' L2 reading comprehension ability, a 33-item test was constructed based on 8 different passages (60 to 400 words in length with various topics) so that the items could assess five different component skills of reading: figuring out main ideas (6 items); locating factual information (i.e., specific details, 11 items); finding out referents of pro-forms (6 items); inferring word meanings from context (4 items); understanding logical relationships among propositions (6 items).<sup>2)</sup> Most of the items were in multiple-choice format, but about 20% of the items (6 in total) required either providing a short answer or marking a specific part of a given text as the answer to a question. The readability grades (calculated using McLaughlin's (1969) formula) for the test texts were between 8 and 11. The reliability (Cronbach's alpha) of this reading test was .84.

### 3.2.3. Measure of Background Knowledge

Several different measures of background knowledge have been used in previous studies (e.g., existence or non-existence of text title in Miller et al. 2006; adaptation of the text into either familiar or non-familiar culture in Alptekin & Erçetin 2013). In the present study, background knowledge was operationalized as the participants' knowledge of the words/phrases appearing in a given text, those directly pertaining to the topic of the text ('topic vocabulary', henceforth). According to Johnston (1984), the knowledge of domain area vocabulary could be the most economical and accurate measure of the reader's prior knowledge. Actually, J Joh (2004) reported a relatively high correlation ( $r=.67$ ,  $p<.001$ ) between topic vocabulary knowledge and reading comprehension performance in L2 among Korean adult English learners. The correlation was almost twice as high

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2) There are different views of component skills of reading comprehension (e.g., Davis 1968; Grabe 1991; Munby 1978, all cited in Alderson 2000).

as that between reading comprehension performance and background knowledge (measured in the readers' L1 by using the questions about the information of high importance in a given text). Such result seems to suggest a facilitating effect of topic vocabulary knowledge in L2 reading comprehension. Referring to Johnston (1984) and J Joh (2004), a test of topic vocabulary was constructed as a measure of background knowledge in which the participants were requested to provide the meaning(s) of the vocabulary items in their L1. Four to twelve core vocabulary items (58 items in total) were extracted from each test text considering the topic of the text as well as the relative length and difficulty of each text.

#### 3.2.4. Measure of L2 Knowledge

Knowledge of syntactic rules and vocabulary in a target language has generally been considered as a major element for successful text comprehension in the language. A total of 60 items (30 items each for grammar and vocabulary) were constructed as the measure of L2 knowledge in the present study. A variety of grammatical features were tapped in the grammar subpart, and the participants were asked to choose the correct form in a given context at the level of sentence or short paragraph. For the vocabulary subpart, the participants were supposed to choose the synonym of a given word in a sentence or a short paragraph, to fill in a gap with a word or phrase that best completes a given sentence or a short discourse, or to find out the word pair that has the same relationship with the example pair. Items for this measure were extracted from the preparation materials for popular standardized English tests with accomplished reliability and validity such as GRE or TOEFL (e.g., *Complete guide to the TOEFL test*, *The official guide to the New TOEFL*). Some items were modified by the researcher where necessary for research purpose. The reliability (Cronbach's alpha) of this measure was .86.

### 3.3. Data Collection

Data were collected in the following manner. Each participant had two meetings with the researcher at the times s/he signed up for. At

the first meeting, a brief survey of demographic information, and the measures of background knowledge and L2 knowledge were administered. Then the reading span task in the participants' L1 was performed, following a practice session for this online task. At the second meeting, the measure of L2 reading comprehension was administered followed by the reading span task in L2. There was no specific time limit for the measures of knowledge and comprehension, but the participants were informed about the recommended length of time for each task, and the variance among the participants in the time spent on completing the tasks was negligible. For the reading span tasks, the participants read silently the sentences one by one on their own speed, but there was limit in the time allowed for them to answer a comprehension question, or to recall the sentence-final words. The mean time spent on the reading span task was 842 seconds for L1 and 990 seconds for L2, respectively.

### 3.4. Data Analysis

#### 3.4.1. Scoring

##### (1) Reading Span Task

The frequency was counted in three areas: the number of correctly recalled sentence-final words as a measure of storage capacity; the number of correctly answered comprehension check-up questions as a measure of processing capacity; and the number of correctly recalled sentence-final words from the sets where the comprehension question was correctly answered, as a measure of composite working memory capacity, shortened as 'composite capacity' in the tables to come.

##### (2) Measure of Reading Comprehension

Each correctly answered item was given 1 point, and with the items that required production, partial score of .5 was given if the answer contained only part of the required information or additionally provided incorrect information as well as correct information.

### (3) Measure of Background Knowledge

A full credit (1 point) was given if the participant provided the very meaning in the same sense as that in the test text, while partial credit (.5) was given if s/he provided only one of the possible meanings but not the same meaning as in the test text.

#### 3.4.2. Inferential Statistical Analysis

A series of correlational analysis were conducted in order to examine the interrelationships among the factors known to affect L2 reading comprehension on one hand, and to investigate the relatedness of each of them to L2 reading comprehension on its own on the other hand. Next, a series of regression analysis were performed as a means to elucidate the unique contribution of each factor to L2 reading comprehension after controlling the possible interrelationships among the factors. Of special interest was whether working memory capacity could uniquely contribute to L2 reading even after controlled for its possible relationships with other traditional factors in reading comprehension.

## 4. Results and Discussion

### 4.1. Overall Characteristics of the Participants

Table 1 shows the descriptive statistics for the variables in the present study. In the table, the numbers in the parentheses next to 'Max.' stand for the highest score possible in each measure.

**Table 1.** Descriptive Statistics for the Variables in the Study

<i>Variables</i>	<i>Min.</i>	<i>Max.</i>	<i>Mean</i>	<i>SD</i>
L2 Knowledge	14	53 (60)	38.03	8.85
Background Knowledge	4	52.5 (58)	31.42	10.68
L2 reading comprehension	10	32.50 (33)	25.54	4.99
L2 storage capacity	0	59 (60)	31.27	15.48
L2 processing capacity	1	15 (15)	10.60	3.35

<i>Variables</i>	<i>Min.</i>	<i>Max.</i>	<i>Mean</i>	<i>SD</i>
L2 composite capacity	0	59 (60)	23.63	15.36
L1 storage capacity	0	51 (60)	26.45	11.98
L1 processing capacity	2	15 (15)	9.88	2.99
L1 composite capacity	0	51 (60)	18.07	10.72

*N=60*

Table 1 indicates that there was less variation among the participants in their L2 reading comprehension ability than in their L2 knowledge or background knowledge. Also, more individual variation was observed in their L2 memory capacity than in L1 counterpart.

#### 4.2. Relationship between L1 and L2 Working Memory Capacity

Research question 1 in the present study concerns whether or not there is specific working memory capacity that could facilitate L2 reading, separate from his/her general working memory capacity. As few previous studies so far have touched this question, the present study examined the relationship between L1 and L2 working memory capacity, using the scores in the reading span tasks constructed in L1 and L2, respectively. Table 2 shows the result of the correlation analysis.

**Table 2.** Correlations among Memory Components

Memory Capacity	<i>L1 storage</i>	<i>L1 Processing</i>	<i>L1 composite</i>	<i>L2 storage</i>	<i>L2 processing</i>	<i>L2 composite</i>
<i>L1 storage</i>	-	.36**	.87**			
<i>L1 processing</i>		-	.63**			
<i>L1 composite</i>			-			
<i>L2 storage</i>	.74**			-	.36**	.88**
<i>L2 processing</i>		.47**			-	.70**
<i>L2 composite</i>			.58**			-

\*\**p*<.01

As shown in the table, there was a moderate to high correlation (.47~.74) between L1 and L2 memory capacity when the memory components were matched. The strength of relationship was in the order of storage (.74), composite (.58), and processing (.47), similar to, but a little different from, Alptekin and Erçetin (2010) where the order was storage (.63), processing (.53), and composite (.35). A possible interpretation for this result is that there could be a substantial covariance between L1 and L2 memory capacity, and that especially one's ability to recall (possibly without understanding, but not necessarily) is quite likely to transfer from L1 to L2, probably more likely than his ability to on-line process incoming language data or the ability to both process and recall it simultaneously. This finding is similar to those in previous studies that reported moderate to high significant correlations between L1 and L2 reading span (Osaka & Osaka 1992; Service et al. 2002).

In addition, the pattern of relationships among memory components was comparable across the languages. That is, while both storage and processing components were fairly highly correlated with the composite capacity (.63~.88), the relationship between the storage and processing component was relatively weak (.36) in both languages. This result implies that the ability to process on-line with comprehension might be different in nature from the ability to recall either with or without comprehension. Also, the correlation between the storage component and the composite capacity was quite high in both languages (.87 and .88, respectively for L1 and L2). This result seems reasonable since, for both the measures, the number of sentence-final words correctly recalled was counted anyway. It is presumably for this reason that several earlier studies used the storage component as a single measure of working memory capacity (e.g., Cain et al. 2004).

#### 4.3. Relationship between L2 Knowledge and L2 Working Memory Capacity

Regarding the nature of working memory capacity in L2 reading, there has been a concern whether it considerably co-varies with one's proficiency

in the target language, or it is rather independent of L2 proficiency (cf. Baek 2013; Payne et al. 2009), though an independent contribution of memory capacity was more often claimed. Table 3 presents the result of correlation analyses between L2 knowledge and L2 working memory components.

**Table 3.** Correlations among L2 Knowledge and L2 Working Memory

<i>L2 working memory</i>	<i>L2 knowledge</i>
Storage	.31*
Processing	.35*
Composite	.32*

\* $p < .01$

As can be seen in the table, there were significant correlations between L2 working memory components and L2 knowledge, but the relationships were weaker than those found between L1 and L2 working memory capacity (cf. Table 1). This result differs from S Baek (2013) a little who found that the processing capacity largely overlapped with L2 proficiency ( $r = .76$ ).<sup>3)</sup> In the present study the overlap between L2 working memory capacity and L2 proficiency was relatively low and comparable across all the three components examined. This result suggests that one's L2 working memory capacity might co-vary more strongly with one's general working memory capacity (measured by an L1 reading span task in this study) than with his/her L2 knowledge.

3) Such difference could be attributed to the different measures used in the two studies in comparison. That is, Baek used a grammaticality judgment task as the measure of processing capacity and a cloze test as the measure of L2 proficiency, while the present study used comprehension check-up questions and a test of syntactic and lexical knowledge, respectively. Also the possible difference in the composition of the sample subjects might be involved.

#### 4.4. Contribution of L2 Working Memory Capacity to L2 Discourse Comprehension

Now that L2 working memory capacity was found more of memory capacity itself than of a covariant of L2 knowledge, it is in order to examine whether it could work as a significant and independent predictor of L2 reading comprehension ability, and, if it does, how much variance in L2 reading comprehension it could explain. As the first step, a correlation analysis was run with L2 reading comprehension performance and all the independent variables put into the analysis. The result is presented in Table 4.

**Table 4.** Correlations between L2 Reading Comprehension and Factors

<i>Factors</i>	<i>L2 RC Performance</i>
L1 storage	.14 (ns)
L1 Processing	.08 (ns)
L1 memory composite	.11 (ns)
L2 storage	.35**
L2 Processing	.39**
L2 memory composite	.40**
L2 Knowledge	.76**
Background Knowledge	.71**

\*\* $p < .01$

As shown in the table, L2 memory components low to moderately correlated with L2 reading comprehension performance, while those of L1 did not, implying that one's working memory capacity in L1 might not directly contribute to his/her reading ability in L2, although there could be a substantial correlation between L1 and L2 working memory capacity. This result partly supports Alptekin and Erçetin (2010) which similarly found out that only L2 working memory composite significantly correlated with inferential understanding in L2, despite the moderate correlation between L1 and L2 working memory capacity. Overall, prior knowledge

(i.e., L2 knowledge and background knowledge) showed high, and much stronger, correlations with L2 reading comprehension than L2 working memory capacity did, indicating that the contribution of L2 working memory capacity to L2 reading comprehension would be less than that of prior knowledge.

Next, a series of regression analysis were run in order to investigate whether L2 working memory capacity is an independent predictor of L2 reading comprehension, even after controlled for its possible correlation with other independent variables. The relative contribution of L2 working memory capacity to L2 reading comprehension would be mined from the analyses, too. Each of the three memory capacity measures was put in a separate regression analysis for the purpose of examining which measure would be a better predictor of L2 reading comprehension.<sup>4)</sup>

The results revealed that the composite working memory capacity (which was defined in this study as the correct recall of sentence-final words while at the same time correctly answering a comprehension question about one of the sentences in the given set) was a significant predictor of L2 reading comprehension, along with L2 knowledge and background knowledge, but not the storage or processing capacity. Even though both of these correlated with the dependent variable almost to the same degree as the composite capacity did, neither of them proved to be a significant predictor of L2 text comprehension ( $t=1.36$ ,  $p=.179$  for storage;  $t=1.51$ ,  $p=.137$  for processing, respectively). This implies that only the composite working memory capacity in L2, but not storage or processing capacity, could be a reliable predictor of L2 reading comprehension, at least among the Korean EFL readers participating in this study.

Table 5 below shows the result of a regression analysis, where the predictors were L2 working memory (=composite capacity), L2 knowledge, and background knowledge. The adjusted  $R$  square of the model was .71 (SEE=2.71), with the  $F$  value of 48.33 ( $df=59$ ,  $p<.001$ ), which means those 3 predictors in the model explained 71% of the total variance in the participants' performance in the criterion measure.

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4) Since none of the L1 working memory components significantly correlated with L2 reading comprehension, only L2 ones were considered in the analyses.

**Table 5.** Relative Contribution of Each Variable to L2 Comprehension

<i>Variables Entered</i>	<i>Beta</i>	<i>T</i>	<i>Sig</i>
L2 Knowledge	.47	3.65	.001
Background Knowledge	.35	2.79	.007
L2 Working Memory (composite)	.15	2.06	.035

As can be seen in the table, L2 working memory on its own accounted for about 15% of the total variance explained by this regression model, suggesting that working memory could be an independent contributor to L2 reading comprehension. This result is similar to Payne et al. (2009), Alptekin and Erçetin (2011), and Swanson et al. (2011) that found out a unique contribution of working memory to L2 reading, either alone or with other variable(s). But it contrasts with Leaser (2007) who claimed that it was topic familiarity, not working memory, which consistently influenced reading comprehension in L2. As Leaser (2007), Alptekin and Erçetin (2011), and the present study all differently operationalized background knowledge,<sup>5)</sup> it is not clear whether the different results are ascribable to the difference in the measure or not. Given these studies were conducted with L2 learners of various L1 backgrounds and proficiency levels, and also with variations in experimental devices, it could be assumed that the role of working memory in L2 reading might vary to a considerable degree depending on the context of research.

Meanwhile, the results of the current study are notably different from those in the recent studies conducted in Korea. For example, S Baek (2013) found out a close overlap between processing component of L2 working memory and English proficiency, and claimed a unique contribution of storage component only, but the present study found less than a moderate correlation between the processing component and L2 knowledge (cf. Table 3). In addition, the storage component did not significantly predicted comprehension ability in L2. Such discrepancy in result could be attributed to the difference in the level of understanding

5) The variable 'background knowledge' in the present study could be considered similar in nature to 'topic familiarity' in Leaser (2007) or 'content-familiarity' in Alptekin and Erçetin (2011).

in the two studies, i.e., sentence comprehension vs. discourse comprehension. However, more research would be needed before such reasoning is confirmed. The present study also differs from J-H Lee's (2014a) study where the processing component only significantly correlated with comprehension, but not either the storage or the composite capacity did. Besides, the correlation was stronger than that between target language proficiency and comprehension. Again, the source of this difference in result might have been the difference in language module by which comprehension was elicited, possibly combined with the difference in the level of understanding, i.e., listening comprehension at sentence level vs. reading comprehension at discourse level, and/or combined with the difference in the measure of target language proficiency. Surely, more empirical studies would be needed to untangle this discrepancy in findings.

## **5. Conclusion**

The main purpose of the present study was to investigate whether one's working memory capacity could predict his/her ability to comprehend L2 discourse, and if so, how much it does and exactly what aspect of it is associated with L2 discourse comprehension. Also of interest was to examine the relationship between one's working memory capacity in L1 and that in L2, and the relationship between L2 proficiency and L2 working memory capacity. By elucidating these interrelationships, and also by including other variables involved in L2 reading comprehension in one design, the present study attempted to systematically and precisely elucidate the role of working memory capacity in the process of L2 discourse comprehension, hopefully answering some of the questions not adequately answered in the previous studies.

Major findings, and tentative conclusions or implications drawn from the findings are as follows. First, there was a moderate to high correlation between L1 and L2 working memory capacity, which varied depending on the memory component being compared, with the highest correlation found between L1 and L2 storage capacity. Both in L1 and L2, the correla-

tion between the processing and the storage component was relatively low ( $r=.36$  in both languages), implying the different nature of these two. From this result, it was concluded that one's working memory capacity in L1 could transfer to L2 to a considerable degree, especially one's storage capacity. Second, L2 working memory capacity showed a relatively low correlation (around .3) with knowledge of L2 structures and vocabulary. As the correlation was substantially lower than that with L1 working memory capacity, it was concluded that L2 working memory capacity is more likely to be of memory capacity *per se* than of an equivalent of L2 proficiency.

Also, L2 working memory capacity moderately correlated with L2 reading comprehension while L1 counterpart did not, despite moderate to high correlations between L1 and L2 working memory capacity. This result suggests that there might be L2-specific working memory capacity that could facilitate L2 reading comprehension. Finally, the participants' composite working memory capacity (i.e., memory capacity satisfying both processing and storage functions) proved to be a significant and independent predictor of their L2 discourse comprehension, accounting for about 15% of the total variance, while neither the processing nor the storage component did. From this result, it was reasoned that the composite L2 working memory could facilitate to an extent L2 discourse comprehension independently and significantly. Even if it might not be a more influential factor than target language knowledge or topic knowledge, it seems clear that it could play an independent and significant role in L2 discourse comprehension.

Although much effort and care was taken to enhance the validity of study, the present research is not free from limitations. First of all, the sample size is not large enough for the findings from the present study to be generalized to Korean EFL learners as a whole, not to speak of L2 readers in general. Also only college students roughly estimated to have high intermediate to advanced level English proficiency participated in this study. If the same research design had engaged other groups of English learners with different age and/or different proficiency level, the results could have been different. Furthermore, the present study used

only expository texts in the measure of reading comprehension, but the role of working memory capacity in L2 discourse comprehension could be different depending on the genre of the text.

Therefore, further research seems necessary to solve the problems that still remain by inviting more L2 learners from a variety of L1 backgrounds, age groups, and proficiency levels. In addition, there seems to be a need to investigate if the role (or contribution) of memory capacity in L2 reading comprehension varies depending on text- or reader characteristics, task types, or different component skills of reading comprehension. Despite these and other unstated limitations, it is hoped that the findings from the present study will shed a light on our understanding of the nature of working memory capacity and its role in L2 discourse comprehension.

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Joh, Jeongsoon

Department of English Education, Konkuk University

1 Hwayang-Dong, Gwangjin-Gu,

Seoul, 143-701

Email: johjs@konkuk.ac.kr

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## Appendices

### 1. Sample Sentences in the Reading Span Task in L2

Korea has many young scientists who are very creative and passionate. Yogurt developed naturally while Africans were carrying milk in leather bags. The number of green building is on the decrease because of their cost. Soccer is like a universal language and most kids know how to play.

### 2. Example Items in the Reading Comprehension Task<sup>6)</sup>

1. Among the four underlined parts, which refers to a different entity from the others?

For many years ①the residents of this state have watched travelers go by, scarcely lifting ②their eyes from the road as they journeyed to resorts in other states. Now ③these people are determined to reap for themselves some of the potential revenue that speeds through their state each year. ④They are planning to make their state attractive to tourists.

#### [2-4] Read and answer.

We can observe that questions such as “Which language do you speak?” or “Which dialect do you speak?” may be answered quite differently by people who appear to speak in an identical manner. Many regions of the world provide plenty of evidence for a puzzling array of language and dialect divisions. Surely socio-cultural factors play a role in determining boundaries. Hindi and Urdu in India, Fanti and Twi in West Africa, Kechwa and Aimara in Peru, to name just a few, are recognized as (A)discrete languages both popularly and in law, yet they are almost identical at the level of grammar. (B)\_\_\_\_\_, the literary and colloquial forms of Arabic used in Iraq, Morocco, and Egypt, or the Welsh of North and South Wales are grammatically quite separate, yet only one language is recognized in each case.

2. Write down in the provided space the word in the text that has the same meaning as the underlined (A)discrete. \_\_\_\_\_

3. Which is the best for the underlined (B)?

① In addition    ② For example    ③ In conclusion    ④ On the other hand

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6) Instructions and stems for the example items were written in Korean.

### 3. Example Items in the Measure of L2 Knowledge

\* Choose the best for the blank.

1. The city of Beverly Hills is surrounded on \_\_\_\_\_ the city of Los Angeles.

- ① its sides    ② the sides are    ③ it is the side of    ④ all sides by

2. People who reverse the letters of words \_\_\_\_\_ to read suffer from dyslexia.

- ① when trying    ② if they tried    ③ when tried    ④ if he tries

16. \_\_\_\_\_ is the opinion people have about how good or bad someone or something is.

- ① appreciation    ② reputation    ③ perception    ④ suspicion

17. Good writing must be coherent. That is, one idea must follow \_\_\_\_\_ and smoothly from the previous one.

- ① intentionally    ② successively    ③ logically    ④ collectively

