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Working Memory and the Learning of English as a Foreign Language: Current Research Practices and Future Directions*

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Choi, Sunhee. "Working Memory and the Learning of English as a Foreign Language: Current Research Practices and Future Directions." ***Studies in English Language & Literature*** **45.1 (2019): 415-437.** Recent years have witnessed a surge of theoretical and pedagogical interest in working memory in the field of English education, and consequently a number of research papers have been published on the role of working memory capacity in Korean speakers' leaning of English as a foreign language. The purpose of this study is to critically review how the existing research on working memory with regard to English learning in Korea has developed over the past decade in an effort to detect the patterns of research practices and to provide insights into future research. To do so, major research databases were searched to find related empirical studies published in peer-reviewed journals and a total of 25 empirical studies were identified. The search results were first described with regard to participants, working memory measures, and targeted English processing and performance measures. The descriptions were then used to detect the patterns of the current working memory research practices with regard to Korean learners' English acquisition. The studies were further analyzed in terms of how differences in WM capacity affect or mediate various aspects of English learning. The results of this critical review will be helpful for researchers in identifying the emerging as well as existing trends of WM and SLA research and thus, planning and conducting their own studies on the topic in the future. (Jeonju University)

Key Words: Working memory, English learning, L2 acquisition, language aptitude, critical review

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I. Introduction

We often wonder why second language (L2) learners under similar circumstances achieve different levels of L2 proficiency. The questions is also applied to the people who somehow learn an L2 more easily and quickly than others. A multitude of cognitive, behavioral, and affective variables have been proposed to explain this phenomenon (Dörnyei, 2005), and intensive research has been conducted to investigate how these variables affect L2 learning success, or lack thereof. Among them, working memory has been one of the major foci of many L2 research studies for the last two decades (Linck, Osthus, Koeth, & Bunting, 2014). In fact, there have been considerable attempts to reconceptualize L2 aptitude, one's ability specific to language learning, via the concept of working memory (WM) which plays an important role in both L1 and L2 processing and proficiency development (Skehan, 2012; Wen, 2015).

Working memory is generally referred to as the mental workspace or cognitive system where "temporary storage and manipulation of information that is assumed to be necessary for a wide range of complex cognitive activities" (Baddeley, 2003, p. 189) takes place. Probably as a central component of language aptitude, working memory capacity is an important dimension of individual difference in L2 learning as well (Miyake & Friedman, 1998). Recent years have witnessed a growing theoretical and pedagogical interest in working memory in the field of L2 learning research in Korea as well. This has been evidenced by an increasing number of both published and unpublished research papers reporting the impact of working memory on the Korean learners' learning of English as a foreign language. Nevertheless, the field is still at an infant stage of development with inconsistent outcomes, and thus, it is high time to review and synthesize the existing studies and reflect on the current research practices for the field to move forward in the right direction.

The purpose of this study is to critically review how the existing research on working memory with regard to English learning and proficiency development in

Korea has developed over the past decade in an effort to provide insights into future research. To do so, major research databases were combed through to find related empirical studies published in peer-reviewed journals and subsequently, a total of 25 experimental and quasi experimental studies were located. The resulted studies were first described with regard to research focus, research design factors such as participants and L2 performance measures, working memory measures, and findings. Such detailed descriptions will be used to detect the patterns of how working memory studies have been carried out and to evaluate the strengths and weaknesses of the current research practice. Next, the impact of working memory on the English use and processing was analyzed in terms of comprehension and production of English by Korean learners. The results of this critical review will be helpful for researchers in finding emerging as well as existing trends of WM and SLA research in Korea and conducting their own studies in the future.

II. Theoretical Backgrounds

2.1 Theoretical Perspectives and Models

There exist slightly different definitions of working memory stemming from different perspectives of the construct. Yet, working memory is commonly referred to as a memory system "responsible for temporary maintenance and manipulation of information" (Juffs & Harrington, 2011, p. 137) while we are engaged in cognitive activities in our daily life, such as arithmetic calculation, comprehending incoming messages, and reasoning on problems (Baddeley & Logie, 1999). Provided that it plays a fundamental role in a wide variety of cognitive processes, several theoretical perspectives and models have been proposed in the fields of psychology and psycholinguistics.

One of the first attempts to theorize the construct and describe its functions came

from Baddeley and Hitch (1974). They proposed a multi-component model with two temporary storage systems, the visuospatial sketchpad and the phonological loop, which were assumed to assist a central executive which has limited attentional capacity (Baddeley, 1992, 2003, 2012). As the names suggest, the visuospatial sketchpad is a short-term storage system used for dealing with visual and spatial information, whereas the phonological loop is specialized for processing acoustic and linguistic information. Both systems hold a small amount of information very briefly, possibly only a few seconds before they lose it. Consequently, in order to maintain the information for a longer period, one needs to make use of rehearsal strategies. These two storage systems are equivalent to short-term memory. The central executive, on the other hand, is a domain-general mechanism whose main function is attention control (Juffs & Harrington, 2011). It is assumed to be responsible for controlling and coordinating information from the other short-term storage components and other cognitive processes including the long-term memory. It also regulates rather limited cognitive resources in order to sustain focus and prevent from getting distracted by the irrelevant information (Cowan, 2005; Engle & Kane, 2012).

Concerned with the functions of the central executive and motivated by studies on linguistic performance by people with impaired phonological short-term memory, Baddeley later modified the original model, first by removing the storage function of the executive, which made the component a essentially attentional system, and then adding a fourth component, the episodic buffer (Baddeley, 2015). The episodic buffer is postulated as an important but passive storage system with limited capacity that can hold information relevant to the ongoing cognitive process (Figure 1). The episodic buffer is suggested as being capable of storing and integrating information from different sources and assumed to be controled and accessed by the central executive in a conscious manner (Baddeley, 2000). Nevertheless, very few studies have been conducted to examine the role of episodic buffer in human cognition, let alone L2 use and processing.

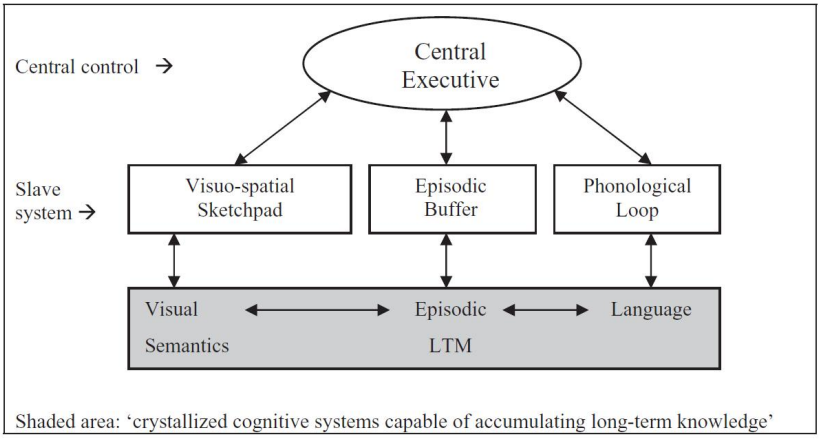

Figure 1. The Current Version of Multi-component Working Memory Model (Juffs & Harrington, 2011, p. 139)

A more recent and increasingly influential model of WM is probably the one proposed by Cowan (2001, 2005) who views the working memory system as process-oriented rather than structural. He insisted that with the multimodal model of WM it is unclear how a stimulus is directed to which storage system (Cowan, 2015). Therefore, instead of assuming that different types of stimulus are assigned to different processing modules in WM, he maintains that a stimulus to be processed activates multiple features in long-term memory. In this view, WM is not a separate memory system, but rather an element in the focus of attention that is highly accessible and available with the limited capacity of holding only a small number of items or chunks (Cowan, 2005).

There exists a strong research tradition in the field of psycholinguistics that investigates the relationship between working memory and first language acquisition, and numerous empirical studies have shown that WM is in fact closely related to L1 acquisition. For example, the phonological working memory (PWM) has been found to play a crucial role in the processing and short-term storage of familiar and new phonological information, which is related to both vocabulary and spoken language

development (Baddeley, 2003; Baddeley, Gathercole, 2007; Gathercole & Papagno, 1998; Speciale, Ellis, & Bywater, 2004). The attentional capacity of the central executive processor, on the other hand, is correlated to sentence and discourse processing as well as reading comprehension (Cowan, 2011; Miyake & Friedman, 1998).

2.2 Roles of Working Memory in L2 acquisition

Driven by the proliferate research outcomes on the relationship between WM and L1 acquisition, a number of SLA scholars have embarked their own journey to find a similar link in L2 learning. Given the attention demanding and consequently more conscious nature of second language learning, it is not difficult at all to predict that WM plays an equally important, or even grater role when one tries to acquire a second language. This particularly feels true if we consider that L2 acquisition requires more mental effort from learners due to learners' ever developing, but still limited lexicon and grammar (Skehan, 2012). Consequently, significant research endeavor has been made to examine the relationship between L2 learning and WM capacity.

In spite of the several different models of WM, as Wen (2012) points out, it is possible to identify a few common characteristics of WM that have to do with language acquisition: limited attentional capacity and multiple components with distinct functions. These two characteristics are most likely to have significant implications for L2 acquisition and consequently, much research effort has been put forth to uncover how they influence the processes and outcomes of L2 learning. This section of the paper, therefore, will be dedicated to the discussion of how each of these characteristics is related to second language acquisition.

First of all, WM is limited in terms of both its storage capacity and duration of holding and processing information. The limited storage capacity of WM is well illustrated by Cowan's argument that WM can hold only 4 chunks of information at a time, also called the magical number 4 ± 2 (Cowan, 2005). The number has

actually been a drastically reduced one from Miller's magical number of 7 ± 2 (Miller, 1956). WM is also limited in terms of the duration it can hold the information. It is generally agreed that information held in WM lasts only a few seconds unless it is rehearsed by a learner. In other words, we can only pay attention to only a small number of stimuli at one time.

This property has significant implications for SLA in that attention to a certain linguistic feature is crucial for language learning to take place and it is also accountable for the ways that learners process linguistic stimuli to which they are exposed (Gass, Svetics, & Lemelin, 2003). Only attended stimuli will be encoded in long-term memory, while unattended ones will persist in working memory briefly and then be discarded. It is generally agreed upon as well that more complex learning requires more attention from learners than simpler learning, and the more learners pay attention to the target form, the better they learn it (Rosa & O'Neill, 1999; Schmidt, 1995, 2001). Given the complexity and attentional demands of learning a second language, it can be predicted that when learners' attentional resources are scarce or their WM capacity is less than optimal, their learning will be compromised.

Secondly, the multi-component aspect of WM is also accepted by most cognitive psychologists. According to the Baddeley's model discussed in the previous section, WM includes qualitatively different, mode-specific information processors: the phonological loop for processing verbally represented materials and the visuospatial sketchpad for dealing with visually represented materials (Baddeley, 1992). These two short-term domain specific channels are managed by the more domain general central executive which controls and coordinates attentional resources of the two short-term storage systems (Baddeley, 2003). There is also a newly added component to Baddeley's model, the episodic buffer. It is quite logical to assume that different components of WM are related to different aspects of language learning given their separate and distinctive roles and functions in processing information, and as a matter of fact, a number of empirical studies have proven so.

To be specific, the phonological and the central executive components of WM are well established to have correlations with various domains of second language acquisition (Linc et al., 2014; Wen, 2015; Williams, 2012) just as in L1 acquisition. For example, an increasing number of studies have reported positive results regarding the relationship between the phonological working memory (PWM) and the acquisition of L2 vocabulary and grammar with the PWM playing an instrumental role in processing and storing novel phonological and morphosyntactic sequences (Ellis, 2012; French, 2006; Williams & Lovatt, 2003). On the other hand, the central executive memory (CWM) has been suggested to facilitate and monitor rather conscious and intentional processes of spoken and written language comprehension and production (Ahmadian, 2012; Miyake & Friedman, 1998, 2012; Sagarra, 2007; Payne & Whitney, 2002). The CWM is also responsible to some extent for post-interpretive discourse level processing such as noticing negative feedback (Goo, 2010; Mackey et al., 2002).

2.3 Measurement of Working Memory Capacity

In order to measure WM capacity, researchers have been using a wide variety of measurement tools that could be categorized into two types: simple span and complex span tests (Juffs & Harrington, 2011; Linck et al., 2014). By asking an individual to recall a series of non-related digits, letters, or words after showing them briefly, simple span tests are supposed to measure one's short-term storage capacity. The examples of simple span tasks include digit span, word span, and non-word repetition tests. However, it should be noted that both word and digit span tests may tap into an individual's prior knowledge in particular if they are presented in the target language, and hence possibly confound study results which are usually correlations between the memory test results and certain forms of L2 proficiency or performance. An alternative to get around this problem is the use of non-word repetition tests in which subjects are presented with and asked to recall a set of

nonsense words (Baddeley, Gathercole, & Papagno, 1998). It is argued since these tests use nonsense words whose sounds are not found in a learner's L1, they could predict learners' abilities with relation to oral performance as well as vocabulary learning (Speciale et al., 2004). Nevertheless, the simple span tests have been criticized in that they only reflect one's capability to store and rehearse information, or so called the short-term memory. Considering that a more recent view of WM includes the domain-general, attention-regulating central executive as well as the domain-general storage components, the complex span tests are more widely used across disciplines these days.

Unlike the simple span tests, the complex span tests determine one's working memory capacity by involving both storage and processing components (Colom, Rebello, Abad & Shih, 2006). They usually require an individual to process incoming input, usually a sentence or a simple mathematical equation, while memorizing target letters, words, or digits simultaneously. Various types of complex span tasks have been utilized in empirical studies over the years, but the best known example should be the reading span test which is basically a combination of word span and reading comprehension tasks. When the reading span test is adopted, participants are presented with a set of sentences and asked to recall a target word in each sentence as well as read the sentences. The to-be-remembered words can be different from the last word or any word in the sentence to prevent participants from making connections and thus creating meanings for better recall. They could also be required to conduct an additional tasks such as deciding on the grammaticality or veracity of the sentence (Conway, Kane, Bunting, Hambrick, Wilhelm, & Engle, 2005). The listening span task uses the same format as the reading span tests, but participants are required to listen to sentences rather than read them (Mackey, Adams, Stafford & Winke, 2010). One caveat of the reading and listening span tasks is that they both rely on an individual's language knowledge, which may falsely increase the correlation between one's WM capacity and the level of language processing or performance. The operation span tasks could help deal with this issue by having

participants work on arithmetic problems while retaining the last words or letters that come with each problem (Turner & Engle, 1989).

The valid and reliable measurement of WM capacity is crucial to understanding the role it plays in L2 acquisition. However, as Juffs and Harrington (2011) point out, several methodological issues should be addressed first to obtain accurate study results. One of them is the way in which memory tests are administered. In many L2 studies, specifically quasi experimental ones conducted outside a controlled laboratory setting, memory tests are often given out to a group of students at the same time. If a complex span task is used with the group administration, there is a great possibility for some students to finish the processing task more quickly and then rehearse the target words until the next set of sentences or problems are presented. This will confound the study results since the results would reflect not only their memory capacity but also strategic abilities. Another important methodological factor to be considered is the scoring of the complex span tests. Traditionally, the reading span test was carried out manually with an absolute scoring method. In this method, credit was given only when a participant remembered all the target words included in a set. This method was criticized for the fact that earned scores were in quite a restricted range of values, and has not been used since the early 2000s (Juffs & Harringtong, 2011). It is now recommended that participants should be tested individually on a computer controlled by an experimenter and that the partial credit scoring method should be applied when calculating an individual's WM capacity (Conway et al., 2005). With this scoring method, participants get credit for each word, not a whole set, they remembered correctly, the comprehension or processing of sentences is checked, and a reaction time is also recorded (Mackey et al., 2002; Miyake & Friedman, 1998). According to Conway et al. (2005), the partial credit scoring method better discriminates individuals with different WM capacities and has higher internal consistency, thus being more reliable (for more in depth discussions regarding different scoring methods, please see Conway et al. 2005).

III. Research Method

3.1 Literature Search

In order to identify the studies that investigated the relationship between WM capacity and learning of English by Korean learners, several electronic databases including RISS, DBpia, Kyobo Scholar, and Korea Scholar were searched. The search was conducted via various combinations of the following key words: English, second language, foreign language, bilingual, working memory, working memory capacity, WMC, working memory span, short-term memory, phonological short-term memory, reading span, listening span, operation span, digit span, and nonword span. The reference lists and the footnotes of the articles located through the search were also examined to locate additional studies cited in them.

For the present review, however, only experimental and quasi experimental studies published in peer-reviewed journals were included, while unpublished masters theses or doctoral dissertations, or papers presented at conferences were excluded for a more sound and reliable review. Studies were also excluded if their major interest was not the relationship between working memory and English learning. For example, Do and Cha (2008) studied the impact of multimedia annotations on English vocabulary learning. Although they took into account the size of the visual working memory for their investigation, their main focus was placed on the effects of multimedia instruction rather than the WMC's contribution to English learning. Nevertheless, these extensive search efforts yielded only 25 empirical studies, which is somewhat surprising given that no restriction was placed on the publication period. It was also noteworthy that all the studies were published in the last 8 years, indicating that the topic is quite new and the field is still at an infant stage of development. The studies reviewed are marked with an asterisk (*) in the works cited.

3.2 Data Analysis

Each of the 25 identified studies was thoroughly examined first and then summarized in terms of variables that could affect the relationship between WM capacity and English learning by Korean learners (see the Appendix for the summary). The variables include participants, WM measures, and targeted English processing and performance measures. As for the participant variable, their age and English proficiency levels are described. Second, in order to measure participants' working memory capacity, the studies included in the present review made use of various types of WM span tasks. The span tasks are described in terms of types (i.e., simple or complex span tasks) and language of performance (i.e., whether the tasks were carried out in Korean or English). Finally, the criterion measures of participants' English processing and performance were examined focusing on different aspects of learning English. The performance criterion measures are also summarized in terms of whether they require learners' comprehension, production, or both. The descriptions were used to uncover the patterns of the current working memory research practices with regard to Korean learners' English acquisition. The studies were further analyzed in terms of how differences in WM capacity affect or mediate various aspects of English learning using the statistical data reported by the studies.

IV. Findings and Discussion

Many of the studies analyzed in this review targeted adult learners, usually college level students, and only 4 of them (Hwang & Choi, 2015; Jung & Choi, 2012; Jung & Lee, 2015; Song & Lee, 2013) recruited primary or secondary school students as their subjects. This could be the result of convenience sampling given that most researchers of the studies worked at universities at the time of their research. One caveat related to this result is that using one particular age group could result in

lack of diversity in terms of English proficiency levels, which could limit the scope of WM-SLA research since it would not be possible to investigate how working memory could operate at different stages of English development. Another area of particular concern is the sample size. As shown in the appendix, the majority of the studies included less than 50 participants with a few exceptions that involved over 100 participants (e.g., Hwang & Choi, 2015; Jeon, 2014; Jung & Choi, 2012). The size is not enough at all for making inferences about the whole population, which is the main purpose of any empirical study. Moreover, considering that the majority of WM studies are correlational in nature, the small sample size could result in the absence of a significant correlation because the possibility to obtain a statistically significant correlations increases as sample size increases (Juffs & Harrington, 2011).

When it comes to measuring working memory capacity, the reading span task was the choice of most studies for assessing complex working memory, whereas the non-word repetition task and the backward digit span task were preferred for measuring the storage component of working memory. Nevertheless, the ways in which these tests were applied are hardly consistent across studies in terms of the language in which the tests were administered, activities used to assess the processing component of complex working memory in the reading span test, and targets of recall for the storage component. For instance, while in some studies the working memory span tasks were conducted in English (e.g., Jeon, 2014; Joh, 2016; Lee, 2014a), in others they were presented in Korean, the learners' first language (e.g., Hyun & Lee, 2018; Kang, 2015; Kim & Cho, 2017). There certainly lacks agreement over what language should be used when administering working memory tests. Some argue that since there is a strong correction between L1 and L2 reading span tasks (Osaka & Osaka, 1992), it is okay to use L1, whereas other are against this idea, maintaining that L2 reading span tasks can confound the relationship between WM capacity and L2 proficiency because comprehending sentences in the reading span tasks requires prior knowledge of L2 (Conway et al., 2005). Another sticking point in relation to WM measurement is a variety of scoring procedures

found in the studies even when they used the same measurements. The lack of consistency in the administration and scoring procedures of WM measures makes it hard to compare and replicate the studies. To address the issue, active discussions regarding WM measurement are required among researchers in addition to more empirical studies using the same measurement tools.

Notwithstanding the somewhat disappointing findings regarding the WM measurement, the review of the studies reveal that there is a promising area as well: various domains of English use and processing were targeted including vocabulary and grammar development (e.g., Park, 2017; Song & Lee, 2013), sentence processing (e.g., Baek, 2014; Choe, 2011), reading comprehension at discourse level (e.g., Choi, 2013; Joh, 2015, 2016), syntactic processing (e.g., Goo, 2014, 2017; Kim & Park, 2016a, 2016b), speaking performance (e.g., Hyun & Lee, 2018), and simultaneous interpreting (e.g., Lee, 2011a, 2011b). Furthermore, several different types of measurement tools were adopted to measure learners' processing and performance in English, which could be both positive and negative. For one thing, more measurement tools will give researchers a chance to discover more reliable and valid ways to assess language processing and development. For another, however, it will again make it hard to compare and replicate studies. Furthermore, the diversity found in the criterion measures paired with a small number of empirical studies means that we do not have enough data for making claims on the relationship between WM and learning English as a foreign language yet. Given the fact that the field is still at an early stage of development as mentioned earlier, the situation is quite understandable, but it still gives us the food for thought on how to advance the field and what needs to be done for the goal.

Of particular interest of the present review was the role that working memory plays in the learning of English by Korean students. A number of studies reported positive results on the roles that WM plays in reading comprehension (e.g., Baek, 2014; Choi, 2013), speaking performance (e.g., Goo, 2017), and grammar learning (e.g., Hwang & Choi, 2015). In contrast, other studies presented statistically

non-significant results. For example, Kim and Park (2016a, 2016b) reported no significant correlation between the island effects and working memory capacity during syntactic processing, while Kim and Cho (2017) showed that the improvement in speaking performance experienced by the participants did not have significant correlation with working memory capacity. Lee (2014) argued that the effect of working memory is task-specific and measurement-dependent in the *wh*-question processing. Despite the discrepancies across the studies, one thing for sure is that a multitude of factors are involved in determining the impact of working memory capacity in learning of English as a foreign language.

V. Conclusion

The principal aim of this review was to analyze the results and findings of the empirical studies conducted on the relationship between WMC and the learning of English by Korean learners, which led to the discovery of strengths and weaknesses of WM-SLA research practices. For this purpose, 25 empirical studies were located through several electronic databases and then summarized in terms of participants, WM measures, targeted English processing and performance domains, and major findings. From this review process, three major observations were derived as follows. First of all, the number of participants was rather small and the range of proficiency levels was limited as well. This limitation can be addressed in future studies by involving more diverse learners with different proficiency levels, which requires conscious efforts from researchers. Another notable but still disappointing finding is that there is no consensus over the tools and procedures used to measure WMC, which made it extremely hard to compare and combine the results of the studies focusing on the same aspects of WM and English learning. This result displays the need for researchers to have more discussions on the measurement issues as well as different aspects of second

language learning. The third observation is that the executive function of WM plays an important role in comprehension processing and real-time production. It is clear from the findings that most empirical studies reviewed here focused on complex working memory rather than on short-term storage component, indicating the importance of processing function carried out by the central executive. The final generalization made from the review of the 25 studies is a disappointing one to some extent in that not all studies reported positive correlation between working memory and the learning of English or the predictive power of working memory in learner performance. Nevertheless, the results of this review are helpful as they help to isolate the possible factors and conditions that could influence the roles of working memory. In conclusion, it is hoped that the findings and discussion in this review make contributions to detecting the patterns of WM-SLA research practices in Korea and hence, moving forward the research endeavor.

Works Cited

Ahmadian, Mohammad J. "The relationship between working memory and oral production under task-based careful online planning condition." *TESOL Quarterly* 46.1 (2012): 165-175. Print.

Baddeley, Alan D. "Working Memory." *Science* 225 (1992): 556-559. Print.

_____. "The episodic buffer: A new component of working memory?" *Trends in Cognitive Science* 4 (2000): 417-423. Print.

_____. "Working memory and language: An overview." *Journal of Communication Disorders* 36 (2003): 189-208. Print.

_____. "Working memory: Theories, models and controversies." *Annual Review of Psychology* 63 (2012): 1-30. Print

_____. "Working memory in second language learning." *Working Memory in Second Language Acquisition and Processing*. Ed. Wen, Mota and McNeill. Bristol, UK: Multilingual Matters, 2015. Print.

Baddeley, Alan D, Susan E. Gathercole, and Costanza Papagno. "The phonological loop as a language-learning device." *The Psychological Review* 105 (1998): 158-173. Print.

Baddeley, Alan D., and Graham Hitch. "Working memory." *Recent Advances in Learning and Motivation.* Ed. Bower. New York: Academic Press, 1974. 47-89. Print.

Baddeley, Alan D., and Robert H. Logie. "Working memory: The multicomponent model." *Models of Working Memory*. Ed. Miyake and Shah. Cambridge: Cambridge University Press, 1999. 28-61. Print.

Baddeley, Alan D., Susan E. Gathercole, and Costanza Papagno. The phonological loop as a language-learning device. *The Psychological Review* 105 (1998): 158-173. Print.

*Baek, Sundo. "Working memory as an independent predictor of second language sentence comprehension." *Korean Journal of Applied Linguistics* 29.4 (2013): 1-25. Print.

*Choe, Mun-Hong. "English L1 and Korean advanced EFL learners' working memory and sentence processing span." *Korean Journal of Applied Linguistics* 27.3 (2011): 29-54. Print.

*Choi, Sungmook. "Working memory capacity, vocabulary knowledge, and reading comprehension of EFL learners." *English Language Teaching* 25.1 (2013): 25-42. Print.

Colom, Roberto, Irene Rebello, Francisco J. Abad, and Pei Chun Shih. "Complex span tasks, simple span tasks, and cognitive abilities: A reanalysis of key studies." *Memory & Cognition* 34 (2006): 158-171. Print.

Conway, Andrew R. A., Michael J. Kane, Michael F. Bunting, D. Zack Hambrick, Oliver Wilhelm, and Randall Engel. "Working memory span tasks: A methodological review and user's guide." *Psychonomic Bulletin & Review* 12 (2005): 769-786. Print.

Cowan, Nelson. "The magical number 4 in short-term memory: A reconsideration of mental storage capacity." *Behavioral and Brain Sciences* 24 (2001): 87-185: Print.

_____. *Working memory capacity*. Hove, UK: Psychology Press, 2005. Print.

_____. "Working memory and attention in language use." *The Handbook of Psycholinguistics and Cognitive Process*. Ed. Loncke & Williams. New York: Taylor & Francis, 2011. 95-97. Print.

_____. "Second language use, theories of working memory and the Vennian mind." *Working Memory in Second Language Acquisition and Processing*. Ed. Wen, Mota and McNeill. Bristol, UK: Multilingual Matters, 2015. 29-40. Print.

Do, Kyung soo and Yu-young Cha. "Effects of visual working memory capacity and the types and contents of graphic annotations on multimedia English learning." *Korean Journal of Cognitive Science* 19.4 (2008): 369-396. Print.
[도경수, 차유영. 「시공간 작업기억 용량과 그림 자료의 유형과 내용이 초등학생의 영어 단어 학습에 미치는 영향」. 『인지과학』 19.4 (2008): 369-396.]

Dörnyei, Zoltán. *The Psychology of the Lanugage Learner: Individual differences in second language learning*. New Jersey: Lawrence Erlbaum Associates, Inc., 2005. Print.

Ellis, Nick C. "Formulaic language and second language acquisition: Zipf and the phrasal

Teddy Bear." *Annual Review of Applied Linguistics* 32 (2012):17-44. Print.

Engle, Randall W. and Michael J. Kane. "Executive attention, working memory capacity, and a two-factor theory of cognitive control." *The Psychology of Learning and Motivation*. Ed. Ross. New York: Elsevier, 2012. 145-199. Print.

French, Lief M. *Phonological Working Memory and Second Language Acquisition: A developmental study of francophone children learning English in Quebec*. New York: Edwin Mellen Press, 2006. Print.

Gass, Susan, Ildiko Svetics, and Sarah Lemelin. "Differential effects of attention." *Language Learning* 53.3 (2003): 497- 545. Print.

Gathercole, Susan E. "Working memory and language." *Oxford Handbook of Psycholinguistics*. Ed. Gaskell. Oxford, UK: Oxford University Press, 2007. 757-770. Print.

Goo, Jaemyung. "Working memory and reactivity." *Language Learning* 60 (2010): 712-752. Print.

*_____. "Corrective Feedback and Phonological Short-Term Memory in the Acquisition of the English That-Trace Filter: A Conceptual Replication of Goo (2012)." *English 21* 27.1 (2014): 231-257. Print.

*_____. "Working Memory and Corrective Feedback in Interaction." *The Journal of Studies in Language* 32.4 (2017): 595-625. Print.

*Hwang, Ji-soo, and Sungmook Choi. "The Effects of Pictures and Working Memory Capacity on Vocabulary Acquisition." *The Journal of Modern British & American Language & Literature* 33.1 (2015): 149-177. Print.
[황지수, 최성묵. 「그림과 작업기억력이 어휘습득에 미치는 영향」. 『현대영미어문학』 33.1 (2015): 149-177.]

*Hyun, Joo-Eun, and Jin-Hwa Lee. "The effects of task complexity and working memory on Korean adult learners' English speaking performance." *English Teaching* 73.1 (2018): 115-134. Print.

*Jeon, Jihyun. "A Study of the Influences of Phonological Short-term Memory and Existing Vocabulary Knowledge on L2 Vocabulary Acquisition." *Journal of Language Sciences* 21.4 (2014): 167-191. Print.
[전지현. 「L2 어휘지식 습득에 있어 음운단기기억과 기존 어휘지식의 영향에 관한 연구」. 『언어과학』 21.4 (2014): 167-191.]

*Joh, Jeongsoon. "Exploring Working Memory Capacity as an Independent Contributor to L2 Discourse Comprehension: A Study of Korean EFL Learners." *Language Research* 51.2 (2015): 443-473. Print.

*_____. "The Role of Text Difficulty and Topic Familiarity in the Contribution of Working Memory to L2 Reading Comprehension." *Korean Journal of English Language and Linguistics* 16.2 (2016): 143-168. Print.

[조정순.「제2언어 독해에 대한 작업기억의 기여에서 지문의 난이도와 소재친숙도의 역할」.『영어학』16.2 (2016): 143-168.]

Juffs, Allan and Michael Harrington. "Aspects of working memory in L2 learning." *Language Teaching* 44.2 (2011): 137-166. Print.

*Jung, Hyunju, and Sungmook Choi. "The interplay of pictures and working memory capacity in vocabulary acquisition of Korean EFL children." *English Language Teaching* 24.4(2012): 255-275. Print.
[정현주, 최성묵.「그림과 작업기억력이 영어어휘습득에 미치는 영향」.『영어교육』24.4 (2012): 255-275.]

*Jung, Hyun-jung and Eun-Joo Lee. "The effects of working memory capacity and types of vocabulary learning on Korean middle school students' English multi-word verb acquisition." *Foreign Languages Education* 22.4(2015): 201-225. Print.
[정현정, 이은주.「작업기억 용량과 어휘 학습 유형이 중학생의 영어 다어동사 습득에 미치는 영향」.『외국어교육』22.4 (2015): 201-225.]

*Kang, Eunsoo. "The Role of Working Memory Capacity Under Implicit Learning Conditions." *Korean Journal of Applied Linguistics* 31.4 (2015): 3-29. Print.

*Kim, Euhee and Myung-Kwan Park. "The Relation between Working-memory Capacity and Island Effects." *The Journal of Linguistics Science* 79 (2016a): 2, 43-70. Print.

*_____. "A statistical test of the relation between wh-dependency resolution and working memory in Korean learners of English." *Korean Journal of English Language and Linguistics* 16.4 (2016b): 851-877. Print.

*Kim, Sowon, and Young Woo Cho. "The effects of recasts and working memory on Korean EFL learners' past tense accuracy." *English Teaching* 72.4 (2017): 105-132.

*Lee, Jin-Hwa. "Task-specific and measure-dependent influence of working memory in Korean college students' English Wh-question processing." *Language Research* 50 (2014a): 815-838. Print.
[이진화.「작업기억과 제2언어 문장처리 간의 관계에 있어서 문장처리 과제 유형과 작업기억 측정 방식이 미치는 영향」.『어학연구』50.3 (2014): 815-838.]

*_____. "Working memory and a subject-object asymmetry in L2 processing of English long-distance wh-questions." *Korean Journal of Applied Linguistics* 30.4 (2014b): 115-139. Print.

*Lee, Migyong. "Working Memory and Individual Differences in Language Processing during Simultaneous Interpreting." *The Translater* 12.1 (2011a): 167-189. Print.
[이미경.「수행기억과 동시통역과정에서의 정보처리의 차이」.『번역학 연구』12.1 (2011): 167-189.]

*_____. "Working Memory Performance of Expert and Novice Interpreters." *Journal of Universal Language* 12.1 (2011b): 95-110. Print.

*Lee, Min Jin. “Relative contribution of working memory capacity to L2 reading comprehension.” *English Teaching* 69.1 (2014): 119-146. Print.

Linck, Jared A., Peter Osthus, Joel T. Koeth, and Michael F. Bunting. “Working memory and second language comprehension and production: A meta-analysis.” Pcychonomic Bulletin & Review 21.4 (2014): 861-883. Print.

Mackey, Allison, Jenefer Philp, Takako Egi, Akiko Fujii, and Tomoaki Tatsumi. “Individual differences in working memory, noticing of interactional feedback and L2 development.” *Individual differences and instructed language learning*. Ed. Robinson. Philadelphia, PA: John Benjamins, 2002. 181-209. Print.

Mackey, Allison, Rebecca Adams, Catherine Stafford, and Paula Winke. “Exploring the relationship between modified output and working memory capacity.” *Language Learning* 60.3 (2010): 501-533. Print.

Miller, George A. “The magical number seven, plus or minus two: Some limits on our capacity for processing information.” *Psychological Review*, 63 (1956): 81-97. Print.

Miyake, Akira, and Naomi P. Friedman. “Individual differences in second language proficiency: Working memory as language aptitude.” *Foreign Language Learning: Psycholinguistic studies on training and retention.* Ed. Healy and Bourne. Mahwah, NJ: Lawrence Erlbaum, 1998. 339-364. Print.

_____. “The nature and organization of individual differences in executive functions: Four general conclusions.” *Current Directions in Psychological Science* 21.1 (2012): 8-14. Print.

Osaka, Mariko and Osaka, Naoyuki. “Language independent working memory as measured by Japanese and English reading span tests.” *Bulletin of the Psychonomic Society* 30 (1992): 287-289. Print.

*Park, Hyangsook. “The roles of retrieval types and working memory in L2 vocabulary acquisition.” *The Journal of Linguistic Science* 82.1 (2017): 59-75. Print.
[박향숙. 「인출유형과 작업기억이 영어 어휘습득에 미치는 영향」. 『언어과학연구』 82 (2017): 159-179.]

Payne, Scott J., and Paul J. Whitney. “Developing L2 oral proficiency through synchronous CMC: Output, working memory, and interlanguage development.” *CALICO Journal* 20 (2002): 7-32. Print.

Rosa, Elena, and Michael D. O’Neill. “Explicitness, intake, and the issue of awareness.” *Studies in Second Language Acquisition*, 21 (1999): 511-556. Print.

Sagarra, Nuria. “From CALL to face-to-face interaction: The effect of computer-delivered recasts and working memory on L2 development.” *Conversational interaction in second language acquisition: A series of empirical studies*. Ed. Mackey. Oxford, UK: Oxford University Press, 2007. 229-254. Print.

Schmidt, Richard. "Consciousness and foreign language learning: A tutorial on the role of attention and awareness in learning." *Attention and awareness in foreign language learning*. Ed. Schmidt, Honolulu, Hawaii, University of Hawaii Press, 1995. 1-63. Print.

_____. "Attention." *Cognition and second language instruction.* Ed. Ronbinson. New York: Cambridge University Press, 2001. 3-32. Print.

*Shin, Jeong-Ah. "Phonological Short-tenn Memory and Second Language Proficiency." *English Language and Linguistics* 18.2 (2012): 127-145. Print.

Skehan, Peter. *Language aptitude. Routledge Handbook of Second Language Acquisition.* Ed. Gass and Mackey. New York: Routledge, 2012. 381-395. Print.

*Song, Bongsun, and Jin-Hwa Lee. "Exploring the relationship between working memory and implicit learning of English." *English Language Teaching* 25.3 (2013): 173-192. Print.

Speciale, Giovanna, Nick C. Ellis, and Tracey Bywater. "Phonological sequence learning and short-term store capacity determine second language vocabulary acquisition." *Applied Psycholinguistics* 25.2 (2004): 293-321. Print.

*Sung, Jee Eun. "Relationship between Working Memory Capacity and Sentence Processing in Normal Adults with English as a Second Language." *Special Education Research* 9.2 (2010): 79-91. Print.
[성지은. 「이중언어 사용 선인의 작업기억용량 개인차가 문장처리 및 자가평가지수에 미치는 영향」. 『특수교육』 9.2 (2010): 79-91.]

Turner, Marilyn L., and Randall W. Engle. "Is working memory capacity task dependent?" *Journal of Memory and Language* 28.2 (1989): 157-154. Print.

Wen, Zhisheng. "Working memory and second language learning." *International Journal of Applied Linguistics* 22 (2012): 1-22. Print.

_____. "Working memory in second language acquisition and processing: The Phonological/Executive Model." *Working Memory in Second Language Acquisition and Processing*. Ed. Wen, Mota, and McNeill. Bristol, UK: Multilingual Matters, 2015. Print.

Williams, Jessica N. "Working memory and SLA." *Handbook of Second Language Acquisition.* Ed. Gass and Mackey. Oxford, UK: Routledge/Taylor & Francis, 2012. 427-441. Print.

Williams, Jessica N., and Peter Lovatt. "Phonological memory and rule learning." *Language Learning* 53 (2003): 67-121. Print.

Appendix

A List and Overview of Reviewed Studies

Studies	Participants	WM Measures	Targeted L2 Processing and Performance
Baek, Soondo (2014)	32 advanced learners living in the US	Reading Span Task	Sentence Processing (Comprehension)
Choe, Mun-Hong (2011)	20 English L1 and 20 Korean advanced learners of English	Word-recall & Comprehension plus-recall tasks	Sentence processing (comprehension and production)
Choi, Sungmook (2013)	46 advanced level college students	Reading span task	Reading comprehension (discourse level)
Goo, Jaemyung (2014)	29 high-intermediate level college students	Non-word repetition task	Syntactic processing (*that*-trace filter)
Goo, Jaemyung (2017)	83 intermediate level adult learners	Operation span task	Syntactic processing (past tense unreal conditional)
Hwang, Ji-soo, & Sungmook Choi (2015)	108 year elementary school students	Backward digit span task	Vocabulary development (receptive and productive knowledge)
Hyun, Joo-Eun, & Jin-Hwa Lee (2018)	20 advance level adult learners	Reading span task (L1)	Speaking performance (picture description tasks)
Jeon, Jihyun (2014)	284 low-intermediate level university students	Non-word repetition task (L2)	Vocabulary development (receptive knowledge)
Joh, Jeongsoon (2015)	60 high intermediate to advance level college students	Reaidng span task (L1 and L2)	Reading comprehension (short passages)
Joh, Jeongsoon (2016)	60 high intermediate to advance level college students	Reading span task (L2)	Reading comprehension (short passages)
Jung, Hyunju, & Sungmook Choi (2012)	105 elementary school students	Backward digit span Task (L2)	Vocabulary development (receptive knowledge)
Jung, Hyun-jung, & Eun-Joo Lee (2015)	60 year middle school students	Digit span task & Nonword repetition task (L1)	Vocabulary development (receptive and productive knowledge of the target words)
Kang, Eunsoo (2015)	24 college students	Reading span task (L1)	Grammar development
Kim, Euhee, & Myung-Kwan Park (2016)	40 college students	Reading span task & N-back task	Syntactic processing
Kim, Euhee, & Myung-Kwan	40 advance level college students	Reading span task & N-back test	Syntactic processing (sentence

Park (2016)			comprehension)
Kim, Sowon, & Young Woo Cho (2017)	42 low to low intermediate college students	Listening span test (L1) and Nonword recall task	Grammar development (speaking performance)
Lee, Jin-Hwa (2014a)	48 college students	Reading span task (L2)	Syntactic processing (comprehension task)
Lee, Jin-Hwa (2014b)	48 college students	Conceptual span task (L1) & Reading span task (L2)	Syntactic processing & listening comprehension of *wh*-question
Lee, Migyong (2011)	16 adult conference interpreters	Listening span task, N-back task, Divided attention test & Irrelevant speech effect test	Simultaneous interpreting English into Korean
Lee, Migyong (2011)	7 experienced and 16 novice interpreters	Listening span task, N-back task, Divided attention task & Irrelevant speech effect test	Simultaneous interpreting English into Korean
Lee, Min Jin (2014)	78 low to high proficiency level college students	Reading span task (L2)	Reading comprehension (discourse level)
Park, Hyangsook (2017)	60 intermediate level college students	Backward digit span	Vocabulary development (receptive and productive knowledge)
Shin, Jeong-ah (2012)	45 undergraduate and graduate students living in the US	Non-word repetition task (L1 & L2)	L2 proficiency
Song, Bongsun, & Jin-Hwa Lee (2013)	24 low intermediate level high school students	Word conceptual span	Grammar development
Sung, Jee Eun (2010)	35 adult learners living in the US	Listening span task & Subtract-2 operation span task	Sentence processing

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