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The Role of Glossing and Working Memory Capacity in Second Language Reading Comprehension

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Glossing, providing information for unfamiliar lexical items to promote reading comprehension, has long been investigated as a textual modification technique to promote second language (L2) reading comprehension. Thus far, however, inconclusive findings have been produced as to whether L2 readers' working memory capacity plays as a moderator of the effects of glossing on L2 reading comprehension. To fill the gap, the present study explored the moderating impact of working memory capacity on the efficacy of glossing in L2 reading comprehension. Eighty-eight Korean university students read two English passages in either a glossed or an unglossed version, while answering multiple-choice reading comprehension items. Participants' phonological short-term memory was assessed with a digit span task and a Korean nonword repetition task, while their complex working memory was measured with a backward digit span task and an automated operation span task. The results of mixed-effects modeling revealed that forward digit span scores moderated the effects of glossing on L2 reading comprehension scores.

Keywords: working memory capacity, glossing, L2 reading comprehension

Introduction

Second language (L2) reading serves an essential role in the development of L2 knowledge, not only as an important receptive language skill but also as a major source of comprehensible input (Krashen, 1982). When learning an L2 as a foreign language, the opportunities to use the language in meaningful and communicative contexts are rare, and thus the centrality of L2 reading in L2 learning becomes even more evident. That said, how to better assist L2 reading comprehension and thereby facilitate the development of learners' L2 competence warrants more empirical investigation. Glossing, i.e., providing semantic information of unfamiliar words in a reading passage in the form of definitions, translations, or synonyms of the words, is one manifestation of pedagogical attempts to enhance L2 reading comprehension. To be more specific, glossing has been proposed as an instructional device to assist learners' bottom-up textual decoding, and in so doing, have positive influence on extract an accurate textual model of the reading passage. Indeed, it is not difficult to find EFL textbooks that incorporate glosses for lexically infrequent words by glossing their meanings in the text margin, and this technique has been widely accepted and utilized in many language classrooms. However, it has largely been left unattended whether and how learners' individual differences, such as working memory capacity, may moderate the efficacy of glossing on L2 reading comprehension. That being the case, the present paper reports findings on whether and how learners' working memory capacity, which is assumed to play a pivotal role in reading comprehension, moderates the effects of glossing on L2 reading comprehension.

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Literature Review

Glossing and L2 reading comprehension

Current theories of reading comprehension entail different layers of conceptual representations, i.e., a textual model that is based on local and text-based information, and a situational model that subsumes both textual information and the reader's prior knowledge, experiences, and attitudes (Kintsch, 1998). Glossing is assumed to function at the local and textual level by means of facilitating the processes of lexical access and meaning retrieval, and thereby assist the assembly of semantic propositions during reading. If readers take advantage of glosses as purported, they will be able to establish an accurate textual model and accordingly richer situational model thanks to the spared mental resources from struggling to figure out the meaning of unknown words. Several researchers pinpointed this issue (e.g., Ko, 2005; Lomicka, 1998). For instance, Ko (2005) suggests that glossing helps L2 readers to spare their limited mental resources by assisting literal understanding of the text, which further promotes the use of inferring strategies.

Previous studies on the impact of glossing in promoting L2 reading comprehension have produced mixed results. Some studies reported facilitative effects of glossing (e.g., Bowles, 2004; Martinez-Fernández, 2010), whereas others failed to find positive influence of glossing on L2 reading comprehension (e.g., Bell & LeBlanc, 2000; Jung, 2016; Jung & Révész, 2018). The inconclusive findings seem attributable to the divergent methodologies that have been employed in the studies. First, different glossing techniques have been utilized in terms of the language used for glossing (e.g., glosses in learners' first language versus the target language as in Ko, 2012), mode of the delivery (e.g., glosses for computer-mediated reading versus paper-based reading as in Taylor, 2009; Wang & Lee, 2020), and tasks embedded in glosses (e.g., multiple-choice glosses as in Liu, 2011; Rott, 2005), to name a few. In addition, the nature of information conveyed in glosses differed across studies, including a simple definition (e.g., Guidi, 2009), a definition followed by an exemplar use (e.g., Hulstijn & Laufer, 2001), a definition accompanied by a photo or a video clip (e.g., Al-Seghayer, 2001), among others. On top of the distinct techniques used for glossing, reading comprehension has also been measured in various ways. To illustrate, reading comprehension measures that have been used in previous studies include free recall in learners' first language (L1) (e.g., Bell & LeBlanc, 2000), free recall in the target language (TL) (e.g., Khezrlou, Ellis, & Sadeghi, 2017), multiple-choice reading comprehension items (e.g., Jung, 2016; Jung & Révész, 2018), and think-aloud comments (e.g., Türk & Ercçetin, 2014).

Lastly, a few variables have emerged as potential moderators of the effects of glossing on L2 reading comprehension. In Jung's studies (2016; Jung & Révész, 2018), for instance, reading comprehension scores were higher for the glossed texts compared to unglossed texts, but the difference was not statistically significant. The null effects of glossing were attributed to the fact that the glossed words were not crucial in answering the reading comprehension questions, and further claim that the efficacy of glossing would surface more clearly when the glossed words are task-essential (Pica, 2002). The wide variety in methodologies and emerging variable that affect the efficacy of glossing on L2 reading comprehension contributed a piece to the inconclusive findings on the efficacy of glossing on L2 reading comprehension, calling for more studies in this field.

Working Memory Capacity and L2 Reading

Working memory can be defined as "a dedicated system that maintains and stores information in the short term, and underlies human thought processes" (Baddeley, 2003, p. 829). In the framework proposed by Baddeley (2000; Baddeley & Hitch, 1974), working memory is comprised of the executive control (i.e., complex working memory), its two connected sub-systems, i.e., the phonological loop and the visuo-spatial sketchpad, and the episodic buffer. Among these, the complex working memory and the phonological short-term memory have received extensive attention regarding their role in the L2 reading

comprehension. The executive control is responsible for controlling the limited attentional resources, carrying out strategic cognitive processing, constant monitoring, intentional learning, and creating solutions to an encountered problem. The phonological loop serves two roles, i.e., storing phonological information temporarily and rehearsing the stored information sub-vocally.

The seminal study on the relationship between working memory and L2 reading comprehension was conducted by Harrington and Sawyer (1992). This study investigated the role of working memory capacity in Japanese EFL learners' English reading comprehension using a digit span test, a word span test (the phonological short-term memory measures), and an L2 reading span test (the complex working memory measure). All three span tests were made in both L1 Japanese and L2 English. The grammar and the reading sections of TOEFL, in addition to a cloze task were used to measure L2 reading comprehension abilities. The correlational analyses showed that the participants with higher L2 reading span scores performed better in the TOEFL reading section, whereas the L2 digit and word span scores shared only marginal correlation with the TOEFL reading scores. Based on the findings, Harrington and Sawyer suggest that complex working memory as an essential component in L2 reading comprehension. In this study, however, both the reading span test and the reading comprehension test were in English, and thus it seems possible to assume that they could have measured overlapping construct, calling for caution in the use of language-dependent tests.

The issue of the inter-dependence of working memory and language proficiency was addressed in Osaka and Osaka (1992) and Osaka, Osaka, and Groner (1993). In Osaka and Osaka's research, L1 Japanese and L2 English speakers completed Daneman and Carpenter's (1980) reading span test in both L1 and L2 versions, and the results showed that there were significant correlations between the two reading span scores. Their follow-up research (Osaka et al., 1993) confirmed a significant correlation between L1 German and L2 French versions of the same reading span test, which led them to conclude that complex working memory may be independent of any specific language proficiency.

Chang et al. (2019) further attempted to identify the sub-component of working memory capacity that is responsible for L2 English reading comprehension by L1 Chinese speakers. In this study, the inhibition function (Stroop, 1935), the updating function (Kirchner, 1958), and the transfer function (Rogers & Monsell, 1995) of working memory were assessed in addition to complex working memory measured with the traditional reading span test (Daneman & Carpenter, 1980). The results of correlational analysis revealed that the verbal working memory capacity and the updating function shared a significant relationship with L2 reading comprehension scores. Based on the findings, Chang et al. claim that maintaining incoming information, making inferences among the propositional units, and retrieval of relevant information from long-term memory require flexible control of the complex verbal memory, and this includes suppressing irrelevant information for more efficient text processing.

While the above studies explored a possible interplay between complex working memory and L2 proficiency in L2 reading, Leeser's (2007) study demonstrated that the effects of complex working memory on reading comprehension might be mediated by the learner's topic familiarity with the given text. In this study, L1 English and L2 Spanish speakers responded to a topic familiarity questionnaire, and their L2 reading comprehension was measured with an L1 free recall task. Waters and Caplan's (1996) computerized version of the reading span test was employed to measure the participants' complex working memory. The results showed that topic familiarity played as a significant factor in L2 reading comprehension. Complex working memory was also shown to have a significant effect on performance on L2 reading comprehension, but only in the familiar condition. The results led Leeser to suggest that L2 readers with higher complex working memory may be able to conjure upon more domain knowledge during reading than those with lower complex working memory.

In a similar vein, in Alptekin and Erçetin's (2009, 2011) studies, content familiarity was shown to improve inferential comprehension, contributing to richer textual representation, but failed to do so for literal comprehension. In addition, complex working memory was shown to correlate with inferential understanding but not with literal understanding. Again, in Varol and Ercetin (2019), readers with low working memory capacity struggled significantly in forming a coherent textual model, leading to poorer

inferential reading comprehension. As aptly pointed by Alptekin and Erçetin (2011), "inferential bridging and elaboration, on their own, place heavier demands on WM as a result of the intrinsic complexity of the tasks they involve" (p. 258), indicating the mediating role of topic familiarity in the relationship between complexity working memory and L2 reading comprehension. This speculation has recently been confirmed by Shin, Dronjic, and Park (2019), in which higher working memory capacity was shown to enable L2 readers to benefit more from relevant background knowledge and thereby obtain better reading comprehension. That said, when examining the effects of working memory capacity on L2 reading comprehension, it seems important to control L2 readers' topic familiarity.

More recently, researchers have explored if L2 readers' working memory moderated the impact of cognitive complexity of the reading tasks on their reading comprehension (e.g., Joh, 2018; Jung, 2018). In Jung (2018), for example, fifty-two Korean university students read TOEFL passages under either a simple (less text subparts to be ordered) or complex (more text subparts to be ordered) condition, while answering reading comprehension questions. The results revealed that when participants had to rearrange more text subparts under the complex condition, those with higher Korean nonword span scores, a phonological short-term memory index, performed significantly better in answering the reading comprehension questions. Based on the results, Jung claims that a larger phonological short-term memory span can store more textual information during reading, which could have facilitated handling text subparts more efficiently. That is, under the increased task complexity, it was found that phonological short-term memory could play as an additional important factor in L2 reading comprehension, in addition to complex working memory, which is a stable explanatory factor in reading comprehension.

Research Questions

The literature review above reveals that previous studies on glossing have generated inconclusive findings as to whether glosses indeed promote L2 reading comprehension as purported by researchers, teaching material developers, and L2 reading teachers. That is, while working memory has been championed as a central component to L2 reading comprehension, the role of phonological short-term memory has not received its due attention from researchers. To fill these gaps in the literature, the present study addressed the following research questions: *To what extent does working memory capacity moderate the impact of glossing on L2 reading comprehension?*

Methodology

Design

This study examined the impact of glossing on Korean university students' L2 English reading comprehension. This study was part of a larger research project on the relationship between various textual modification techniques to promote L2 reading comprehension and L2 lexical learning, and hence shares several methodological resemblances with previous studies (e.g., Jung, 2016, 2018; Jung & Révész, 2018). Participants were randomly assigned to either glossed or unglossed condition and read two reading passages, while answering multiple-choice reading comprehension items.

Participants

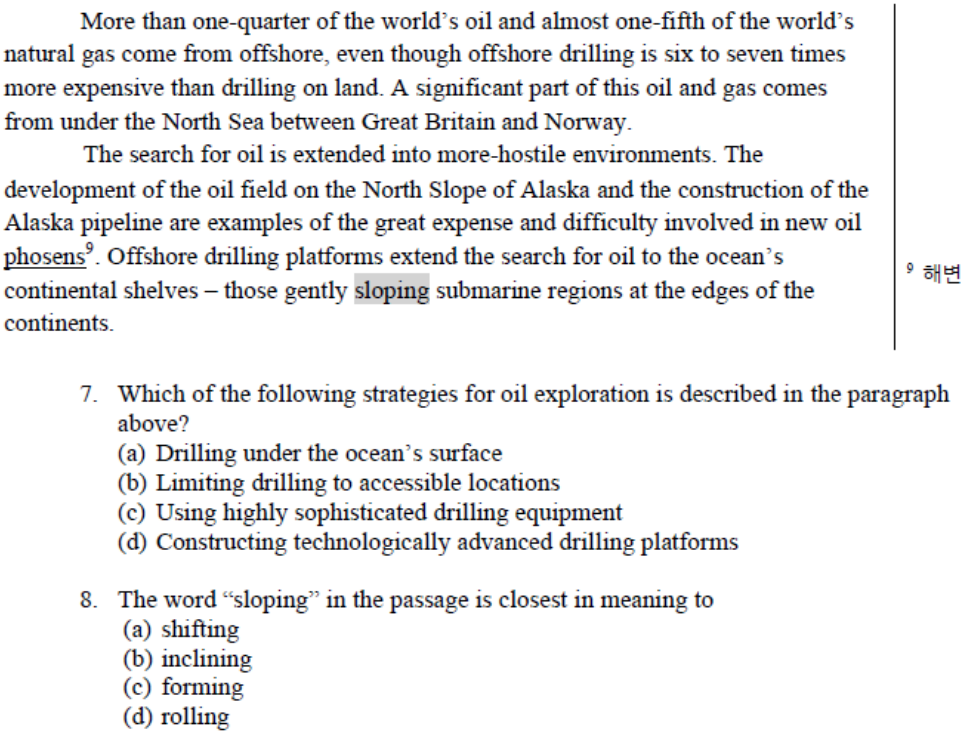
The participants included 88 (53 male and 35 female) university students in Korea. Their L1 was Korean, and their average age was 23.69 (*SD* = 3.67). They were majoring in different subjects under the faculty of Art and Humanities, including Economics, Sociology, Politics, and Arts and Design. The average onset age of English learning was 9.45 years old (*SD* = 2.52), and they did not have experience of

residing in an English-spoken country, which was a condition for participating in this study. Their average TOEFL score was 97.4 (*SD* = 4.56), indicating that their L2 proficiency was high-intermediate. The participants' English proficiency was assessed with a modified Reading and Use of English section of a practice Cambridge Proficiency: English (CPE) test (Cronbach's alpha = .68). Based on the scores from this test, stratified random sampling was used to guarantee that the glossed and the unglossed groups did not differ in terms of their English proficiency.

The Texts and Reading Comprehension Measures

For this study, two reading passages were extracted from a TOEFL practice guidebook (Educational Testing Services, 2013). Text 1 descried the formation and processing of petroleum resources, and text 2 explained the evolutionary explosion during the Cambrian period. The two texts were deliberately chosen to prevent confounding impact of topic familiarity on reading comprehension (Leeser, 2007), considering that the content of the texts was likely to be unfamiliar to the participants of this study, who were mostly from the faculty of Art and Humanities. The number of words was 682 for Text 1 and 699 for Text 2, and the Flesch-Kincaid readability index of each of the texts was 10.6 and 12.6, respectively. Considering that the participants of the present study were high-intermediate level English speakers, the two texts were considered appropriate in terms of readability. To cancel out any ordering effect, the order of the two texts was counter-balanced within each group.

As in the TOEFL setting, each text was split into five subsections, followed by two to three multiple-choice reading comprehension items (see Figure 1). The multiple-choice reading comprehension items were also taken from the same TOEFL practical book developed and tested by ETS to increase validity and reliability of the items (Freedle & Kostin, 1999). There were nine multiple-choice comprehension items for each reading passage, and the full score was 10 (1 point for 8 items and 2 items for one item). Cronbach's alpha of reading comprehension scores for Text 1 was .57 and that for Text 2 was .52.



More than one-quarter of the world's oil and almost one-fifth of the world's natural gas come from offshore, even though offshore drilling is six to seven times more expensive than drilling on land. A significant part of this oil and gas comes from under the North Sea between Great Britain and Norway.

The search for oil is extended into more-hostile environments. The development of the oil field on the North Slope of Alaska and the construction of the Alaska pipeline are examples of the great expense and difficulty involved in new oil phosens[9]. Offshore drilling platforms extend the search for oil to the ocean's continental shelves – those gently sloping submarine regions at the edges of the continents.

[9] 해변

7. Which of the following strategies for oil exploration is described in the paragraph above?
   (a) Drilling under the ocean's surface
   (b) Limiting drilling to accessible locations
   (c) Using highly sophisticated drilling equipment
   (d) Constructing technologically advanced drilling platforms

8. The word "sloping" in the passage is closest in meaning to
   (a) shifting
   (b) inclining
   (c) forming
   (d) rolling

Figure 1. Sample reading comprehension test item.

Glossing

In order to examine the effects of glossing on L2 reading comprehension scores, ten lexical items were selected from the two texts (see Table 1). The target lexical items were pseudo-words that replaced original words in the two texts. The words were selected if (a) the word is a noun so that the part of speech could be controlled, and (b) the word appears only once to control the input frequency. Then, the words were replaced with pseudo-words to control the participants' prior knowledge. In addition, to control the word length, all of the pseudo-words contained two syllables. Glossing was constructed by providing Korean translations of the words in the text margin.

TABLE 1
Target Pseudo-words (source: Jung, 2016; Jung & Révész, 2018)

	Text 1			Text2	
	Pseudo-word	Original word		Pseudo-word	Original word
1	stragon	bottom	1	cabrons	changes
2	golands	spouts	2	fration	absence
3	phosens	discoveries	3	zenters	clues
4	klaners	parks	4	morbits	descendants
5	stovons	beaches	5	tralion	predator

Working Memory Measures

In this study, the phonological short-term memory was measured with a digit span test and a Korean nonword repetition test and the complex working memory was assessed with a backward digit span test and an automated operation span test.

Forward digit span test (DS)

The forward digit span test was adopted from Brunfaut and Révész (2015). In this test, sequences of random digits were presented on an automated PowerPoint slide show. Each digit was shown for 1 second, and set sizes increased from 3 to 11 digits. Participants had to write down the digits for each set, following a beep sound after each set of digits. Ten seconds were allowed for recalling each set. The maximum set size that was correctly recalled at least once was the DS score. Cronbach's alpha for this test was .73.

Korean nonword repetition test (NWR)

In the Korean nonword repetition test, nonsense words that were consistent with Korean phonotactic rules were shown to participants in an automated PowerPoint slide show. The test contained 32 nonwords, and each of the words consisted of 4 (e.g., 해곡충버 *hae-gok-choong-boe*) to 11 syllables (e.g., 라코만스탄지서무동구란 *ra-ko-man-su-tan-ji-soe-moo-dong-goo-ran*). Each nonword was aurally and randomly played to the participants, and they were instructed to orally recall what they just heard. The maximum number of syllables of a nonword that was correctly recalled at least twice was the NWR score. Cronbach's alpha for this test was .79.

Backward digit span test (BDS)

The overall structure and procedure of the backward digit span test was the same as the forward digit span test (Brunfaut & Révész, 2015), but participants had to recall the digits in reverse order in this test. The maximum set size correctly recalled once was the BDS score. Cronbach's alpha for this test was .84.

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Automated operation span test (OSPAN)

In the automated operation span test (see Figure 2), participants were instructed to solve a math problem while remembering a set of unrelated alphabetic letters (Redick, Broadway, Meier, Kuriakose, Unsworth, Kane, & Engle, 2012; Unsworth, Heitz, Schrock, & Engle, 2005). To ensure that the participants experienced a trade-off between storage (remembering letters) and processing (solving math problems), an 85% of accuracy rate was set as a criterion for the math operation. The test session consisted of three sets, set sizes ranging from 3 to 7 letters, and the order of set presentation was random. Following Unsworth et al. (2005), the total number of correctly recalled letters was the OSPAN score. Cronbach's alpha for this test was .78.

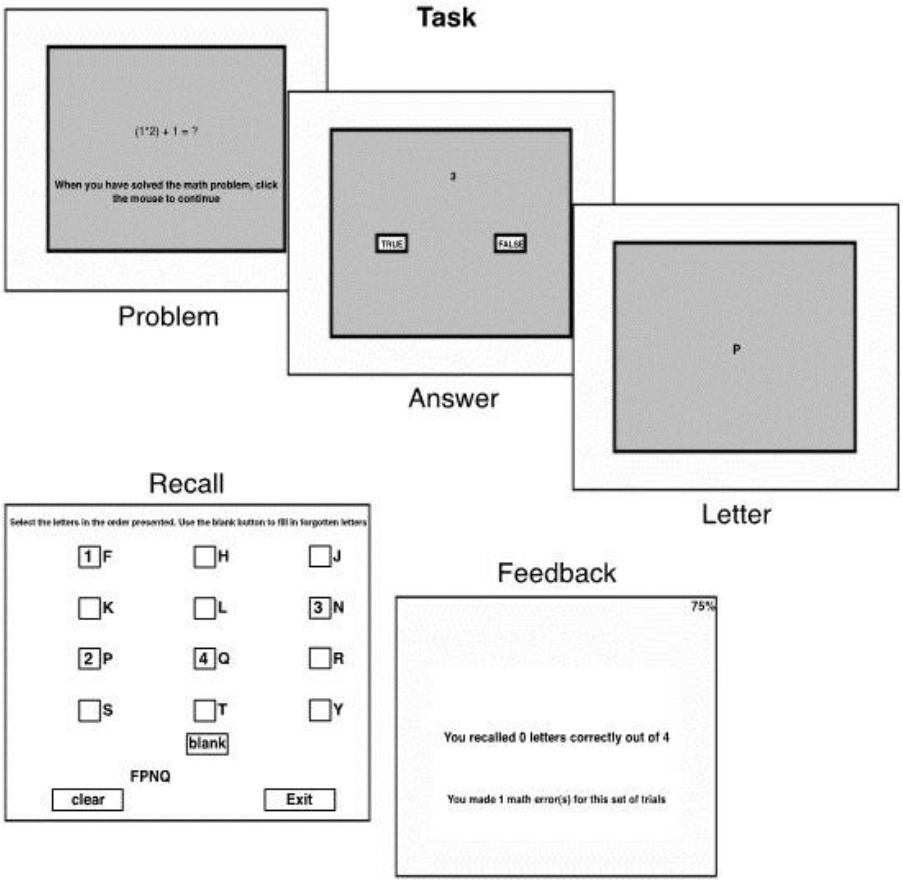

Figure 2. Example of slides used in the OSPAN test (Source: Adopted from Unsworth et al., 2005, p. 500).

Procedure

The data for this study were collected over the period of three sessions. In the first session, participants answered a background questionnaire and the modified CPE test. One week later, they read the two TOEFL passages and answered the relevant multiple-choice comprehension items. Two weeks later, the participants carried out the four working memory measurements. Approximately an hour was taken to complete each session. All sessions were conducted in a computer-laboratory at a university in Korea.

Analysis

SPSS 22.0 (Statistical Package for Social Sciences) for Mac was used for calculating reliability of the

tests (Cronbach's alpha) and performing descriptive and correlational analyses (Pearson's coefficients) of the data. The significance for this study was set at the level of $p < .05$. The main data analyses were conducted by constructing various mixed-effects models using the *lmer* function in the package *lme4* (Bates, Maechler & Bolker, 2012). As linear mixed-effects model summaries provide t statistics without *p*-values, absolute *t*-values above 2.0 was set for testing significance of the models (Gelman & Hill, 2007). Effect sizes for the models were examined with the *r.squaredGLMM* function in the package *MuMln* (Barton, 2015).

Results

Prior to the main data analyses, it was checked whether the two groups were equivalent in terms of their L2 English proficiency. The mean proficiency score was 8.66 for the unglossed group (*SD* = 3.30, 95% CI[8.07, 9.25]), and 8.77 for the glossed group (*SD* = 3.97, 95% CI[8.18, 9.36]). The results of a likelihood ratio test revealed that Group did not make a significant difference to the null model, $\chi^2(1) = 01$, $p = .99$. That is, the groups were comparable with each other in terms of their CPE scores.

The descriptive statistics for the reading comprehension scores are presented in Table 2. It was shown that the participants performed slightly better on Text 2 than on Text 1. The table also showed that participants in the glossed group performed better than those in the unglossed group. In order to inspect if glossing had facilitative impact on L2 reading comprehension scores, linear mixed-effects modeling was conducted with R. The results of likelihood ratio test using χ^2 statistics demonstrated that glossing did not promote reading comprehension scores for both Text 1 ($\chi^2(1) = 68$, $p = .41$, $R^2 = .28$) and Text 2 ($\chi^2(1) = 24$, $p = .63$, $R^2 = .21$).

TABLE 2
Descriptive Statistics for Reading Comprehension Scores by Group

		Text 1			Text 2		
Group	*N*	*Mean*	*SD*	95% CI	*Mean*	*SD*	95% CI
Unglossed	44	5.84	2.06	[5.25, 6.43]	6.02	1.73	[5.43, 6.16]
Glossed	44	6.16	1.48	[5.57, 6.75]	6.20	1.79	[5.61, 6.79]
Total	88	5.94	2.04	[5.52, 6.36]	6.11	1.75	[5.69, 6.53]

Note. Maximum score = 10.

Next, to see if the working memory indices tapped related constructs, Pearson's correlation coefficients were computed for DS, NWS, BDS, and OSPAN scores. As summarized in Table 3, DS, NWS, and BDS scores were shown to correlate significantly with each other. For OSPAN scores, however, significantly correlation was found only with BDS scores. That is, DS, NWS, and BDS scores were shown to reflect common constructs, i.e., phonological short-term memory capacity. Also, BDS and OSPAN scores appeared to share common construct, i.e., complex working memory capacity.

TABLE 3
Correlations between WMC Measures

		DS	NWS	BDS	OSPAN
DS	Coefficient	1	.46**	.44**	.17
	Significance		.00	.00	.13
NWS	Coefficient		1	.35**	.17
	Significance			.00	.11
BDS	Coefficient			1	.39**
	Significance				.00
OSPAN	Coefficient				1
	Significance				

Note. DS: forward digit span scores, NWS: Korean nonword repetition scores, BDS: backward digit span scores, OSPAN: operation span scores, Significance level: +$p < .1$, *$p < .05$, **$p < .01$.)

In order to see if working memory moderated the efficacy glossing on reading comprehension scores for Text 1, another series of likelihood ratio tests were performed with χ^2 statistics. Null models included Glossing as an existing fixed effect, in addition to Subject and Item as random effects. To the models, each of BS, NWS, BDS, and OSPAN scores was entered one by one to see if the inclusion improved model fit significantly. As summarized in Table 4, the results indicated that DS scores significantly improved the reduced model on reading comprehension scores for Text 2.

TABLE 4
Interaction between Glossing and WMC Measures on RC Scores

		χ^2	*df*	*p*	R^2
Text 1	DS	8.86	2	.01*	.28
	NWS	5.30	2	.07$^+$	.28
	BDS	1.18	2	.56	.28
	OSPAN	2.92	2	.23	.28
Text 2	DS	1.39	2	.50	.21
	NWS	1.46	2	.48	.21
	BDS	.17	2	.92	.21
	OSPAN	5.19	2	.07$^+$	.21

Note. Significance level: $+p < .1$, $*p < .05$, $**p < .01$.

Next, a maximal structured linear mixed-effects model was constructed including Glossing and DS scores as fixed effects and Subject and Item as random effects. As shown in Table 5, significant effects of interaction emerged between Glossing and DS scores on reading comprehension scores for Text 1. R^2 of the model was .28, indicating medium model fit for the data.

TABLE 5
Interaction between Glossing and DS Scores on RC Scores for Text 1

	Fixed effects			Random effects	
				by-Subject	by-Item
	Estimate	SE	*t*	*SD*	*SD*
Intercept	.60	.24	2.47°	.03	.26
Glossing	1.33	.45	2.96°	.07	–
DS	.00	.02	.24	–	–
Glossing*DS	-.14	.05	-2.91°	–	–
Formula: *RC ~ Glossing * DS + (Glossing | Subject) + (1 | Item); R^2 = .28.*					

Note. Significance: °| t | > 2.0.

In order to examine the function of DS scores in reading comprehension scores between glossed and unglossed conditions, post-hoc mixed-effects modeling was conducted. As presented in Table 6, significant contribution of DS scores to reading comprehension scores for the glossed condition, but not for the unglossed condition. In other words, when glosses are provided, participants with higher DS scores were significantly better at finding correct answers to the reading comprehension questions for Text 1. R^2s were .23 and .32, which were evaluated as fit for the data.

TABLE 6
Interaction between Glossing and DS Scores on RC Scores for Text 1

		Fixed effects			Random effects	
					by-Subject	by-Item
		Estimate	SE	*t*	*SD*	*SD*
Unglossed	Intercept	.58	.26	2.22°	.02	.13
	DS	.01	.03	.44	–	–
Formula: *RC ~ DS + (DS|Subject) + (DS|Item); R^2 = .23.*						
Glossed	Intercept	-.07	.39	-.18	.16	.28
	DS	.08	.04	2.00°	–	–
Formula: *RC ~ DS + (DS|Subject) + (DS|Item); R^2 = .32.*						

Note. Significance: °| *t* | > 2.0.

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Discussion

This study addressed the mediating role of working memory capacity in the effects of glossing on Korean learners' reading comprehension of English texts. Glossing was conducted by providing Korean translations for ten pseudo-word items that replaced ten original nouns in the texts. Working memory capacity, subsuming both phonological short-term memory and complex working memory, was included as a potential moderator of the effects of glossing on reading comprehension scores. The results revealed that reading comprehension scores were slightly higher in the glossed condition in comparison to the unglossed condition, but the differences were not big enough to be statistically significant. Floor effect could have veiled the influence as reflected in the relatively low mean scores. It may need to be reminded that the participants were highly homogeneous in terms of their English proficiency, rendering it limited to expand variances in the scores between the glossed and unglossed conditions. Moreover, given the small number items (9 items, 10 points) for each text, the chances to observe any meaningful impact of glossing on reading comprehension could have been largely confined. That said, in future studies, a greater number of items might be required to observe how glossing affects L2 readers' text understanding.

It might be also noteworthy that the glossed words could have not been crucial in answering the multiple-choice reading comprehension items. As discussed earlier, task-essentialness (Pica, 2002) emerged as an important factor moderating the impact of glossing on L2 reading comprehension. That is, when the glossed items are crucial for completing the task, such as answering reading comprehension items or establishing a complete text understanding, L2 readers will attend better at noticing and processing information provided by glosses, enhancing the efficacy of glossing (Jung, 2016; Jung & Révész, 2018). That said, if the target items were chosen based on the degree of essentialness for successful reading comprehension, the effects of glossing might have been more likely to surface. This is a pedagogically important issue, as glosses are commonly and widely incorporated in many ESL/EFL textbooks regardless of the inconclusive research findings. Hence, to generate not only theoretical but also pedagogical insights on the usefulness of glossing in L2 reading, it seems imperative to conduct more studies on the relationship between task-essentialness and the effects of glossing. Given that technical terms or difficult words are glossed in the current TOEFL reading test, it would be interesting to examine if the efficacy of glossing would change depending on the language used for glossing (e.g., Ko, 2012) or learners' L2 proficiency.

When it comes to the moderating effects of working memory capacity, the correlational analysis revealed that the two phonological short-term memory indices (i.e., the digit span test scores and the Korean nonword repetition test scores) correlated significantly with the backward digit span scores. This appears to indicate the common underlying cognitive mechanism, that is, storage of phonological information in the short-term memory. Also, the backward digit span test scores and the automated operation span test scores were shown to share significant correlations, which manifests their loading on the controlled processing and manipulation function of the complex working memory.

The results from the mixed-effects models further showed that forward digit span scores had a moderating effect on reading comprehension scores for Text 1. It seems noteworthy that the mean reading comprehension score was lower and the variance was larger for Text 1 than those for Text 2, presumably contributing to the increased likelihood to observe any moderating influence of working memory capacity. Considering that most studies have addressed the importance of complex working memory, rather than phonological short-term memory, in L2 reading comprehension, the finding of this study warrants particular attention. The findings seem to cast light on the importance of phonological short-term memory capacity to store and retain lexical meanings provided by glosses and thereby perform better in L2 reading comprehension. In other words, at the initial decoding stage of reading (e.g., word recognition and lexical access), readers with limited vocabulary knowledge may benefit more from glosses if they have larger phonological short-term memory, which enables them to more construct propositions from the text more efficiently. In addition, it might be possible to assume that complex working memory was crucial for comprehending for both glossed and unglossed texts to a comparable extent, resulting in the absence of significant difference in its contribution (i.e., backward digit span scores and operation span

scores) between the two experimental conditions. Considering that the significant moderating role of forward digit span scores materialized only for the reading comprehension scores for Text 1, it would be required for future studies to include reading comprehension tests that have higher reliability and discriminability among the learners to that the precise role of working memory capacity can be demonstrated.

Conclusion

The present study, of course, is not free from limitations. For one, the construct of L2 reading comprehension in this study was treated as a monolithic entity, and not decomposed into its sub-components, namely, literal and inferential comprehension. Given that previous studies have supported differential contributions made by glossing or working memory capacity to successful L2 reading comprehension (e.g., Alptekin & Erçetin, 2009, 2011; Ko, 2005; Leeser, 2007), future studies may need to include the two dimensions of L2 reading comprehension to better spell out the effectiveness of glossing and working memory capacity in L2 reading comprehension. In addition, the reliability of the multiple-choice reading comprehension items was relatively low, underscoring the need for caution when generalizing the findings of this study and hence the importance of replication of this study in the near future. Also, the participants had overall high TOEFL scores, and thus it should be noted that they could have been very familiar with TOEFL reading tests. That said, future studies may need to incorporate other types of reading comprehension tests, especially when participants have relatively high TOEFL scores. Last but not least, as discussed above, the glossed words turned out to be not essential for understanding the texts and answering the reading comprehension items, which should be addressed in the follow-up studies.

Regardless of the limitations aforementioned, the present study unveils the potential significance of forward digit span as a moderator of the efficacy of glossing on L2 reading comprehension. As commented earlier, most previous studies have explored the role of complex working memory, while somewhat neglecting the role of phonological short-term memory in reading comprehension. This study manifests that the importance of phonological short-term memory might be emphasized when it comes to taking advantage of the lexical meanings provided through glosses.

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