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Interplay of Working Memory, Strategy Use, and Task Difficulty in L2 Reading Comprehension

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In pursuit of the precise mechanism by which working memory (WM) functions in second language (L2) reading comprehension (RC), the current study examined whether strategy use or task difficulty influences the role of WM in L2 RC. Eighty Korean adult EFL learners participated, and their WM capacity, RC performance, and strategy use were measured. The variable of task difficulty was operationalized by the relative difficulty of texts on which RC items were based. The results showed that difference in strategy use brought about significant difference in RC performance when the readers with insufficient WM capacity had to comprehend difficult texts, whereas no such difference was found with easier texts or among L2 readers with more WM capacity. These findings not only illustrate intricate interrelationships among WM and other variables in L2 RC, but also provide a noteworthy implication for L2 reading instruction that L2 learners with deficient WM capacity could benefit from active strategy use when faced with a difficult L2 reading task. The compensatory role of strategy and the necessity of remedial strategy training for the learners with limited WM is further implicated for L2 reading classrooms.

Keywords: working memory, L2 knowledge, strategy use, task difficulty, L2 reading comprehension

Introduction

Working memory (WM) has been actively investigated in the cognitive psychology of reading since Daneman and Carpenter (1980). Although debates are still going on about its construct and exact functions (Wen, 2016, p. 11), WM is often seen as an important cognitive process that engages in encoding, storing, and retrieving of information, which is "essential for learning and higher-level processing of information" (Dehn, 2008, p. 58). In relation to reading comprehension, it has been conceived of as a prerequisite for processing textual coherence, and as an integral part of language comprehension that affects the ability to remember new information acquired while reading (Daneman & Hannon, 2007). According to Cain, Oakhill, and Bryant (2004), WM makes it possible to access knowledge from long-term memory, hold it to connect to newly incoming information, and make inferences about the new information. Some researchers further cited WM as one of the critical elements that constitute L2 proficiency outcomes (DeKeyser & Koeth, 2011; Skehan, 2015).

Since 1990's, WM has attracted L2 researchers, too, as a possible predictor of success in L2 acquisition and comprehension, and the results often indicated that WM positively contributed to various aspects of L2 processing (Ahmadian, 2012; Alptekin & Erçetin, 2009; Harrington & Sawyer, 1992; Rai, Loschky, Harris, Peck, & Cook, 2011; Verhagen & Leseman, 2016). Despite a general consensus that WM could be a potential variable that can explain L2 comprehension, there arose a need for more meticulous

examinations of WM's role in L2, largely because of the discrepancies in research findings regarding the specific manners in, or circumstances under, which WM plays a role. One of the major issues was whether WM's contribution to L2 reading comprehension (RC, hereafter) is unique and independent, or influenced by other factors involved in L2 comprehension, such as reader's preexisting knowledge, affective factors like motivation and interest, and strategy use, to name a few.

Target language knowledge and knowledge of the reading topic, among others, were most frequently explored as possible factors that moderate the relationship between WM and L2 outcomes, and the results were mixed. While some researchers reported an independent main effect of WM on L2 RC (e.g., Alptekin & Erçetin, 2011), others found out WM's contribution was influenced by topic familiarity (e.g., Leeser, 2007). Compared to these knowledge variables, relatively less is known about other factors in light of their moderating role in WM's contribution to reading comprehension. Only recently, small number of studies reported the influence of task-relevant characteristics on WM's role in L2 comprehension (e.g., Cho, 2017; Jung, 2018; Lee, 2014). Much less has been discussed about the role of strategy in relation to WM's function in L2 contexts. Strategy seems to deserve more attention, however, for at least two reasons. Firstly, it has long been claimed to have a facilitating effect on L2 acquisition and comprehension (e.g., Ahmadi, Ismail, & Abdullah, 2013; Phakiti, 2003; Zare & Othman, 2013). Secondly, some researchers maintained that strategy could compensate for deficiency in WM capacity while reading, especially by facilitating inferring processes (e.g., Burton & Daneman, 2007; Cain et al., 2004). Considering the common belief that the ability to utilize strategies can be improved by training (e.g., Carrell, 1998; Pani, 2004; Taylor, Stevens, & Asher, 2006), while WM is constraint in capacity and rather stable, figuring out the possible interplay of WM and strategy use would provide a clue to understanding the complicated nature of L2 reading process. Therefore, the present study aims to investigate whether and how WM interacts with strategy use in the process of L2 reading comprehension. Additionally, the present study also examines whether task difficulty plays a role in this process, as strategy use might vary according to task variables (e.g., Oxford, Cho, Leung, & Kim, 2004; Rouhi, Jafarigohar, Alavi, & Asgarabadi, 2015). By including these variables simultaneously in one design, the current study intends to enhance our knowledge of the precise mechanism by which WM functions in L2 reading.

Review of Literature

Working memory has often been associated with language acquisition and processing. Skehan (2015) described it as "a buffer for language input and output" (p. 189), and Miyake and Friedman (1998) and Juffs (2015) regarded it as a possible explanation for individual differences in L2 learning. A considerable body of recent studies investigated the role of WM in L2 acquisition at various levels, with the majority dealing with syntactic rules or lexical items (e.g., Denhovska, Serratrice, & Payne, 2016; Mackey & Sachs, 2012; Martin & Ellis, 2012).

The possibility of interaction between WM and other variables also attracted L2 researchers. Variables such as input modality, feedback type, and manner of learning were investigated as a possible moderator of WM's role in L2 processing or learning (e.g., Denhovska et al., 2016; Kozan, Erçetin, & Richardson, 2015; Li, 2013; Révész, 2012; Yilmaz, 2013). Several previous studies implied that WM's impact on L2 processing might vary according to target language proficiency or the target structures examined in the study (Dussias & Pinar, 2010; Felser & Roberts, 2007; Hopp, 2014; Sagarra & Herschensohn, 2010).

In the studies focusing on the relationship between WM and L2 reading comprehension, one important issue concerns whether WM's contribution to L2 reading comprehension is unique and independent, or it is moderated by other factors in L2 comprehension. Knowledge of target language and that of text topic, among others, have most frequently been investigated as a possible moderator. Previous studies on this issue have yielded mixed results. Although Linck, Osthus, Koeth, and Bunting (2014) concluded that there was little difference in the correlation between WM and L2 learning outcomes that can be attributed to learners' proficiency, different findings were also reported (e.g., Payne, Kalibatseva, & Jungers, 2009;

Swanson, Orosco, Lussier, Gerber, & Guzman-Orth, 2011; Walter, 2004). While Payne et al. (2009) claimed WM independently influenced L2 reading regardless of previous L2 learning, Walter (2004) found out substantial difference between lower and higher proficiency L2 learners in L2 WM capacity and transferability of L1 reading skills to L2, suggesting an intricate interrelationship among WM, L2 proficiency, and L2 reading comprehension. In addition, the facilitating effect of WM capacity on L2 processing was claimed more salient with low proficiency L2 learners in Hummel (2009), and Weissheimer and Mota (2009), while recently Joh and Plakans (2017) found the opposite.

Long recognized as a facilitator of language comprehension, background knowledge has also been investigated as a factor that can influence the relationship between WM and language processing, both in L1 and L2, revealing inconsistencies in findings (Alptekin, & Erçetin, 2011; Hambrick & Engle, 2002; Hambrick & Oswald, 2005; Leeser, 2007; Miller, Cohen, & Wingfield, 2006). For example, Leeser (2007) found that the WM's impact varied as a function of topic familiarity, with the consistent influence of topic familiarity on L2 reading comprehension, whereas Alptekin and Erçetin (2011) found out an independent contribution of both WM and background knowledge. More recently, Joh and Plakans (2017) suggested a possible interaction between WM and topic knowledge.

Meanwhile, several recent studies attend to task-related variables (e.g., task type, task mode, task difficulty, etc.) with an interest in the possible interaction between WM and task variables in L2 RC. For example, Jung (2018) investigated the effects of task complexity and WM capacity on L2 RC and found no influence of task complexity on L2 RC but a significant facilitating effect of phonological short-term memory on the performance in the complex task, implying an interaction between task complexity and memory capacity. Jung's (2018) finding is rather contrastive of Joh's (2016), where WM significantly predicted L2 RC only in the task accompanying easy L2 texts about familiar topics. However, such comparison needs caution, largely because the measures of memory capacity and task complexity in the two studies were not identical. Cho (2017) examined task modality as well as task complexity in search of their impact on L2 performance, with additional interest in the moderating role of WM in the process. Results indicated a significant effect of task complexity on most aspects of L2 performance, but non-consistent effect of task modality and neither a significant main or moderating effect of WM on L2 performance. These recent studies report discrepant findings about the relationship between WM and task variables in L2 processes, requiring further studies on this issue.

Unlike the knowledge or task variables, strategy use has rarely been included as a factor in WM studies, especially in L2 contexts. Although it has long been recognized as an important facilitator of various aspects of L2 acquisition, including L2 RC (e.g., Khoshsima & Tiyar, 2014; Malcom, 2009; Shang, 2010), studies that examined strategy use in relation to WM's function in L2 reading are not easily found. Based on a study involving L1 adult learners, Naumann, Richter, Christmann, and Groeben (2008) claimed that WM capacity was a prerequisite for strategy training to be effective in learning. Burton and Daneman (2007) reported how metacognitive behaviors compensated for L1 English speakers' low WM capacity, suggesting that strategy use could facilitate reading process for those whose WM capacity is limited. These previous studies provide insights regarding the possible interplay between strategy use and WM in reading comprehension or learning, but both were conducted in L1 contexts, leaving much to be further explained about their relationship in L2 reading process.

WM studies for the past few decades have indicated highly sophisticated nature of WM by revealing intricate relationships among WM, factors in L2 processing, and various aspects of L2 proficiency. It is probably for this reason that Linck et al. (2014) and Wen (2016) called for further investigation in search of the factors that possibly affect the relationship between WM and outcomes of L2 reading/learning. As shown in the review of literature, not many WM studies conducted in L2 contexts have included strategy use or task variables, in contrast to the plethora of WM studies involving knowledge variables, whether it is the knowledge of the L2 or that of text topics (often interchangeably used with *background knowledge* or *content familiarity*). Considering, however, the well-evidenced impact of strategy in overall L2 learning, and the research findings that report the possible effect of task-related variables on L2 outcomes, more studies seem necessary that include those variables, for a more comprehensive view of WM's role

in L2 learning and comprehension. Given this, the present study posed the following two research questions:

(1) Does the effect of WM on L2 RC vary as a function of strategy use?
(2) Does task difficulty moderate the interaction, if any, between WM and strategy use?

Method

Participants

Participants were 80 students (31 male and 49 female; freshmen to seniors at the average age of 21.3) enrolled in a university in Korea. Most were education majors (50, with various specializations), and the rest 30 were from various majors, e.g., liberal arts, social or natural sciences, and engineering. Their target language (i.e., English) proficiency was roughly estimated as high-intermediate to advanced, based on their scores on the Korean Scholastic Aptitude Test or from a standardized English proficiency test, such as TOEFL or TOEIC.

Instruments

Measure of WM capacity

The participants' WM capacity was assessed using a computerized reading span task. The reading span task (RST) has been commonly used as a measure of WM capacity since Daneman and Carpenter (1980). In the present study, the span task consisted of 60 separate English simple sentences, all of which were 8 to 13 words in length, statements in active voice, with all sentences being different in the final words, and with all final words being different in their first sound. Most of these sentences were from the English textbooks for Korean high school students, except for several sentences from the previous studies. Care was taken to make the sentences comparable in difficulty. Following the common practice in the previous studies, the present study started from Level 2 (*Level* means the number of sentences in a set.), extending up to Level 6, and there were three sets of sentences in each *Level*.

For the RST, the participants were instructed to read each sentence as it appears on a computer screen, to answer a comprehension question at the end of each set (i.e., the measure of processing capacity), and then to recall all the sentence final words in the given set (i.e., the measure of storage capacity). A comprehension question was asked about one of the sentences in a set, and the location of the stimulus sentence was varied across sets. Participants pressed the space button as a signal to move on to the next step when they finished reading a sentence, answering the comprehension question, or recalling the sentence-final words. There was time limit for the last two steps so that the program would automatically proceed to the next step if a participant does not press the space button within the limit, which was 6 and 10 seconds, respectively. Participants' responses to the comprehension questions and their recalling of sentence-final words were audio-recorded for later transcription and analysis.

Each participant's WM capacity was determined by combining three components, i.e., processing, storage, and time (i.e., speed of sentence reading). First, the number of correctly recalled sentence-final words was counted only from the sets where the processing task (i.e., the comprehension question) was satisfactorily performed (cf. Leeser, 2007; Swanson, 2013). Then, the mean sentence reading time was calculated for each participant as an indicator of sentence processing speed to be included as a component of WM capacity (cf. Waters & Caplan, 1996). Finally, one's WM capacity was defined in terms of a

composite Z-score that included both the time component (i.e., averaged sentence-reading time) and processing-storage component.[1]

Measure of L2 reading comprehension

The participants' L2 reading comprehension ability was assessed using a 33-item test which was based on 8 different passages on various topics. The passages were 60 to 400 words long, and their readability grades were between Grade 8 and 11 on McLaughlin's (1969) formula.[2] Five different reading subskills above the decoding level were implemented into items across the reading passages: 6 items for inferring main ideas; 11 items for locating specific details; 6 items for identifying referents of pro-forms; 4 items for contextual inferring of word meanings; and 6 items for understanding logical relationships among propositions. Most items were multiple-choice type, but 6 items (about 20%) required a short answer in writing. For these 6 items, a partial score was allowed if the response was considered to provide part of the expected answer. The reliability of this measure proved to be high, .87 in terms of Cronbach's alpha.

Measure of target language proficiency

The present study narrowly defined target language proficiency (interchangeably used with 'L2 proficiency', or 'L2 knowledge', hereafter) as the participants' knowledge of target language syntactic structures and vocabulary items. L2 proficiency is such a broad term, and researchers have adopted a variety of ways of operationalizing its construct. Among many possible components of knowledge or ability that comprise L2 proficiency, one's knowledge of grammatical structures and lexical items were considered the major linguistic knowledge components that make reading comprehension in the language possible.

A 60-item test (30 each for structures and vocabulary) was constructed to assess L2 proficiency. All the items were of multiple-choice type, selected from the existing test preparation materials for well-known standardized English proficiency tests such as *TOEFL*. Efforts were exercised so that the selected items could sample various English structures or vocabulary items as much as possible. For the structure items, the participants were instructed to choose the grammatically correct form for a blank in a sentence or a short paragraph, while for the vocabulary subpart, the participants chose the synonym for a given word in a sentence or a short paragraph, selected a word or phrase that best completes a given sentence or a short paragraph, or chose the word pair that parallels the example in its relationship. The reliability of this measure was .89 (Cronbach's alpha).

Measure of strategy use

Strategy use was appraised using a 60-item strategy checklist which was developed by Joh (2012). This checklist was constructed based on the existing reading strategy inventories (e.g., Anderson, 1999; Lee & Oxford, 2007; Mokhtari & Sheorey, 2002; Pritchard & O'Hara, 2008). Those overlapping items across the inventories were combined into one and modified appropriately, and certain items were excluded that were not directly related to an actual activity of reading a given text but rather describing L2 learning in general (e.g., 'I plan what I am going to accomplish in English reading each day or each week'). Finalized 60 reading strategies were re-phrased in the past tense for them to form a post-reading checklist of strategy use.

[1] On this scale, if two participants have the same number of correctly recalled sentence-final words while successfully completing the processing task, then the one who spends less time reading the sentences would be considered to have more WM capacity than the other who spends more time.

[2] In this formula, the readability is calculated basically by counting the number of words containing three or more syllables from the beginning, the middle, and the last part of a given text.

In this measure, the participants were instructed to mark on each strategy in the list, using one of the 4 scales (i.e., '0' for "I never did this."; '1' for "I did this only occasionally."; '2' for "I sometimes did this.": '3' for "I often did this."), as an indicator of their strategy use while performing the given RC task. The mean strategy use was calculated for each participant first by summing up the marked number on each strategy item, and then dividing the sum by the total number of items in the checklist. This mean was encoded to represent an individual participant's strategy use.

Measure of task difficulty

Task difficulty was narrowly operationalized in the present study as text difficulty, and was determined by the relative difficulty (i.e., readability grade) of the test texts used in this study. Namely, of the 33 RC items based on 8 texts, the 17 items accompanying four texts of higher readability grade (mean grade 11) were regarded *difficult*, and the rest (mean grade 8.5), *easy*. Since the format and the nature of the items in the RC task was almost identical across the test texts, it was assumed that the linguistic difficulty of texts could entail task difficulty. Accordingly, the role task difficulty could play in the relationship among working memory, strategy use, and L2 RC was examined by comparing the results of the statistical analyses run for the participants' performance on the higher and lower difficulty items, respectively. As the number of items were not identical across the two difficulty levels (i.e., 17 vs. 16), raw scores were converted into percentage for the sake of comparison (cf. Table 2).

Procedure

The researcher met the participants individually for data collection, twice for each participant, at the times they chose. An agreement form and a demographic information survey were filled out at the first meeting, followed by the administration of L2 knowledge measure. A test of L2 reading comprehension and a reading span task were performed at the second meeting. There was a short practice session for the reading span task before administering the task, as it was not familiar to most participants. Based on the pilot administration of the measures, 30 minutes was allowed for the L2 knowledge measure, and 50 minutes for the measure of reading comprehension. The difference among the participants in the time spent on completing the measures was negligible.

Data Analysis

First, the participants' performance was scored for each of the measures as described in the previous section, and then, a series of ANCOVA were conducted. As the sample size was not large enough to include a three-way interaction term, only WM and strategy use were put into the model as factors, with L2 knowledge being entered as a covariate. The reason that L2 knowledge was included in the model was that, as mentioned earlier in this paper, previous studies have often observed the moderating role of target language proficiency in the relationship between WM and L2 learning or processing. There were two levels (either higher or lower) for each independent variable (i.e., WM and strategy use), and the participants were assigned to one of the two levels based on their score on the given measure. The median was used as the criterion of grouping. In the first step of the statistical analysis, the participants' scores for the all 33 items in the RC measure was entered as the dependent variable, with a special interest in a possible interaction between WM and strategy use in the variance of participants' L2 RC. Then, with a view to examining if task difficulty plays a role in the relationship among WM, strategy, and L2 RC, the same analysis was conducted again for each of the two sets of data: i.e., the participants' performance on the *Easy*, and the *Difficult* task, respectively. For this purpose, the participants' performance on the 17 items accompanying the higher readability texts were encoded separately from their performance on the rest 16 items that accompanied the lower readability test texts. The variables and the measures used to define them are presented in Table 1.

TABLE 1
Summary of Variables and Measures

Variables	Measures	Subtotal	Total
L2 Knowledge			60
	Vocabulary	30	
	Syntax	30	
Working Memory	Reading span	-	60[3]
Strategy Use	Post-reading strategy check list	-	60
L2 RC			33
	Main idea	6	
	Specific information	11	
	Referent	6	
	Contextual inference	4	
	Coherence marker	6	

Results and Discussion

In this chapter, descriptive statistics for the measures employed in the current study is presented, and then the results for the two research questions posed follow, along with discussion on them.

General Descriptions of Participants' Performance on the Research Measures

Table 2 is a summary of descriptive statistics for the measures used in the current study.

TABLE 2
Descriptive Statistics for Research Measures

Variables		Lowest	Highest (Max.)	Mean	SD
L2 RC		10	32.50 (33)	25.54	5.00
L2 Proficiency		14	53.00 (60)	37.76	8.33
Working Memory		0	59.00 (60)	22.81	14.54
(Process-Storage)	High	23	59.00 (60)	35.53	8.73
	Low	0	22.00 (60)	11.31	7.30
Strategy Use		.36	2.20 (3.0)	1.23	0.40
	High	1.26	2.20 (3.0)	1.57	0.23
	Low	.36	1.80 (3.0)	.94	0.25
Task difficulty	Difficult	25.00	100 (100)	62.86	19.78
	Easy	26.70	100 (100)	86.95	13.53

Research Question 1: WM Effect by Strategy Use

As mentioned earlier, the participants were assigned either to lower or higher level on each independent variable according to their performance in the relevant measure. A two-way ANCOVA was run, with WM and strategy use entered as factors, and target language knowledge as a covariate. As can be seen in Table 3 in the below, there was no significant main or interaction effect for the entered factors, although the model itself explained a considerable variance in L2 RC, the dependent variable. The only significance was found with L2 knowledge, which was included as a covariate.

[3] The number reported in relation to WM in this table is about the processing-storage components only.

TABLE 3
WM and Strategy Use in L2 RC

Sources	SS	Df	MS	F	Sig.
L2 knowledge	904.457	1	904.457	101.996	.000
WM	26.235	1	26.235	2.959	.090
Strategy Use	3.487	1	3.487	.393	.533
WM x Strategy Use	14.572	1	14.572	1.643	.204

R^2 = .606 (Adjusted R^2 = .585)

Different from previous studies that have reported the facilitating effect of WM and/or strategy use on L2 reading comprehension, the current study did not find a significant influence of either factor on L2 RC, not to speak of significant interaction between the two factors. This result suggests that neither the difference in WM capacity nor that in strategy use efficiently differentiated the participants' L2 reading performance, at least in the specific context of the current study. Also, strategy use did not influence the impact of WM capacity on L2 RC, as indicated by the non-significant interaction between the two. According to the result, the participants' performance on the L2 RC was determined largely, and significantly, by their knowledge of the target language.

Several reasons for this result could be tracked down. First, most previous studies conducted correlation or regression analyses to examine the relationship between WM/strategy use and RC, while the current study employed ANCOVA, in search of a possible interaction between the independent variables in their impact on RC. For running ANCOVA, the sample was divided into two levels within a factor, i.e., WM capacity or strategy use, both of which were based on continuous data, not nominal[4] in nature. This could have masked to an extent, if weakly, the actual relationship between the variables. More specifically, the distinction between the two levels in the present study might not have been strong enough to distinguish the two subgroups on the given variable, as all the participants were assigned anyway to one of the two levels. This means that some participants whose scores lay around the median could have diluted the contrast between the groups, although this procedure was rather unavoidable due to the relatively small sample size. If those participants at the borderline had been removed in the analysis to make the two groups sharply distinctive of each other on the given variable, the result might have been different. Such intervention, however, could result in the reduced power of the model itself, as is often the case with analyses involving small number of entities.

Research Question 2: WM and Strategy Use by Task Difficulty

The second research question concerned whether task difficulty plays a certain moderating role in the manner WM and strategy use operate in L2 reading comprehension. As mentioned earlier, two separate ANCOVAs were conducted to answer this question, and the results were closely compared in pursuit of such possibility. First, an ANCOVA was run with the participants' performance on the easier items in the L2 RC test being entered as the dependent variable, representing *Easy Task*. The result is given in Table 4.

TABLE 4
Result for Easy Task

Sources	SS	Df	MS	F	Sig.
L2 Knowledge	4997.934	1	4997.934	43.442	.000
WM	210.105	1	210.105	1.826	.181
Strategy Use	137.496	1	137.496	1.195	.278
WM x Strategy Use	.905	1	.905	.008	.930

R^2 = .403 (Adjusted R^2 = .371)

As Table 4 shows, the result was similar to that where the performance on the whole RC items was entered as the dependent variable (cf. Table 3), i.e., no significant main or interaction effect found for the

[4] Examples of nominal variables include gender, nationality, or teaching treatment, etc.

factors of interest, and the only significance was found with the covariate, implying again that only the knowledge of the target language significantly explained the participants' comprehension of the easier texts, but neither their WM capacity nor strategy use did. Although similar over all, minute differences also existed between these two sets of result. Namely, with *Easy* task, the significance level of the main effect for WM was higher and R^2 value for the model was much lower. The latter part implies that the explanatory power of the entered variables was rather weak, and that there could be additional variables that would explain the participants' performance on the *Easy* RC task.

Another ANCOVA was run next that entered '*Difficult Task*' as the dependent variable, which was represented by the participants' performance on the more difficult items on the L2 RC test used in the current study. The result is summarized in Table 5.

TABLE 5
Result for Difficult Task

Sources	SS	Df	MS	F	Sig.
L2 Knowledge	12122.840	1	12122.840	61.060	.000
WM	639.932	1	639.932	3.223	.077
Strategy Use	701.645	1	701.645	3.564	.064
WM x Strategy	1333.581	1	1333.581	6.717	.011

R^2 = .519 (Adjusted R^2 = .493)

As can be seen in Table 5, a considerably different result was observed when the task was difficult (cf. Refer to *Table 4* for the result for *Easy Task*). Although the main effect for WM capacity or strategy use still did not reach statistical significance, the values were closer to the significant level, compared to those found with *Easy Task*. Most importantly, the interaction between WM and strategy use was significant. Table 6 shows how such interaction was realized.

TABLE 6
Interaction between WM and Strategy Use in Difficult Task

WM	Strategy Use	Mean	SE	Lowest	Highest
Low	Low	54.15	3.011	48.15	60.15
	High	65.81	3.822	58.19	73.43
High	Low	67.96	3.598	60.79	75.13
	High	65.20	3.462	58.29	72.09

Table 6 illustrates how task difficulty moderated the effects of WM or strategy use on the participants' comprehension of L2 texts. The above result indicates that when L2 readers had relatively sufficient WM capacity, strategy use did not critically influence their reading comprehension performance in the L2, as can be seen in the comparable means between the two strategy groups within the high WM group (i.e., 67.96 vs. 65.20). That is, if L2 readers have sufficient WM capacity, it may not be crucial in their RC performance whether they are high strategy users or not. By contrast, the apparently large difference between the two strategy groups within the low WM group (i.e., 54.15 vs. 65.81) suggests that strategy use may considerably facilitate L2 RC performance, compensating for their deficiency in WM resources. Table 6 further reveals that the high strategy users with lower WM capacity performed similarly to the participants of higher WM capacity (i.e., 65.81 vs. 65.20 or 67.96), once again supporting the possibility that active strategy use may compensate for inadequate WM capacity.

This finding seems to have a meaningful implication for L2 teachers and learners. Previous research has proved that deficiency in WM may lead to difficulty in comprehension or learning (Cowan, 2014; Gathercole & Alloway, 2008), and WM is generally considered constraint in capacity and rather stable within an individual. Furthermore, even L2 readers with good WM capacity may not be successful in a comprehension task unless they are equipped with sufficient knowledge of the L2 or of the text topic (Joh & Plakans, 2017). On the other hand, strategy is almost the only area, among many individual factors that can influence one's achievement in L2 learning, that is likely to improve by means of instructional

intervention, e.g., training in the classroom. What Table 6 suggests is a possibility that strategy use could contribute to better comprehension performance of L2 readers who do not have much WM resources, when they are faced with a difficult target language text or task.

In sum, the results presented in Table 4 through 6 imply that the roles of WM or strategy use in L2 RC can vary as a function of task characteristics. Although we have seen for the past decades how WM's contribution to (L2) reading or learning can be moderated by other factors, the current study adds another perspective to this issue, by indicating how task characteristics can influence the relationship among WM, strategy use, and L2 RC. This is not simply figuring out the moderating role of a variable in the interaction of the other variables, but rather discovering an evidence for the facilitating effect of strategy use in L2 RC from a different point of view. Further research seems necessary, however, that analyses a three-way interaction among WM, strategy use, and L2 knowledge, since the interaction between WM and strategy use might vary as a function of the readers' L2 knowledge level, as well as task difficulty.

Conclusion and Implication

For the past three decades of WM studies in the context of L2 acquisition or processing, one of the major issues has concerned whether and how WM's impact varies as a function of other factors known to play a role in L2 reading. Target language proficiency and topic familiarity (also labelled as *background knowledge*, *topic knowledge*, or *domain knowledge* in different studies to represent a similar, if not identical, construct) have most frequently been highlighted, among others, as a potential moderator of WM's role in L2 reading, with mixed results. The present study attempted to extend the query by examining strategy use and task difficulty in one design. These two factors have not been adequately investigated together with WM in the context of L2 reading, although previous L2 studies have quite often recognized them either as a facilitator or as a moderator in the process or product of L2 reading comprehension. Major findings from this study are summarized as follows.

When the participants had to complete a reading task involving relatively easy L2 texts, none of the entered factors revealed a significant main or interaction effect, with an exception of target language proficiency which was entered as a covariate. By contrast, when they were engaged in a similar type of reading task accompanying relatively difficult L2 texts, there was a significant interaction between WM and strategy use, where the reading performance was not affected by strategy use among those participants with higher WM capacity whereas it WAS among those with lower WM capacity. More specifically, more active users of reading strategies within the lower WM capacity group performed significantly better on the difficult task than less active strategy users in the same group, which was contrastive of the non-significant difference in the reading performance within the higher WM group which could be attributed to strategy use. Those participants with lower WM capacity who actively used reading strategies were even comparable with higher WM participants in their performance on the difficult task. This significant interaction effect deserves attention given the non-significant main effects of WM or strategy use found in the current study, both of which variables have often been associated with successful L2 processing or learning. A reasonable assumption based on this result would be that L2 readers with insufficient WM capacity are likely to benefit from active use of reading strategies when given a difficult reading task.

An important pedagogical implication that can be drawn from the current study is that strategy use could compensate for deficiency in WM capacity, facilitating L2 reading process when a reading task gets difficult. One of the common beliefs among L2 researchers is that effective strategy use could enhance various aspects of L2 learning and that the ability to use strategy can be trained. Given this, the current study reminds a need to introduce an instructional remedy program in L2 reading classrooms that directly aims at reading strategy training, with its empirical support for the facilitating effect of strategy use on L2 reading, especially for those L2 learners with limited WM capacity facing a rather difficult reading task. Even though strategy has often been emphasized as one of the major factors in L2 learning achievement,

this study provides an empirical support for such view from a new perspective, i.e., by explicating the role of strategy in relation to WM capacity.

Several limitations of the current study should be mentioned. First, relatively small sample size made it difficult to analyse a 3-way interaction among L2 proficiency, WM, and strategy use, as a function of task difficulty. Additionally, distinction of the lower vs. higher group in the examined variables was not enough to effectively contrast the two groups in the variable of interest, due to those participants around the median score who were assigned anyway to one of the two groups. Second, the manner each variable was defined may have affected the result, too, in that other methods of eliciting strategy use or different operationalizations of task difficulty would have yielded different results. There could be other limitations associated with the process of data collecting as usually is the case in studies that involve human subjects.

WM has been proved to explain a considerable portion of L2 reading performance, which means deficiency in WM may cause difficulty in reading L2 texts. The effectiveness of WM training has not yet been confirmed, however, implying one's memory capacity may not be easily enhanced by training (cf. Morrison & Chein, 2011; Swanson, Kehler, & Jerman, 2010). Given this, the finding from the current study that active strategy use led to significantly better performance on a relatively difficult L2 reading task could be motivating to L2 teachers as well as those L2 readers who suffer from insufficient WM capacity. Further studies seem necessary that involve a larger sample of L2 learners from various backgrounds, and thereby overcome shortcomings of the current study. Ongoing research that meticulously investigates the interwoven relationships among WM and other variables in diverse L2 contexts will increase our knowledge of WM, and also provide useful insights on how to help L2 learners when they engage in L2 reading tasks and L2 learning in general.

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