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Word-Nonword Phonological Memory and L2 Proficiency*

Misun Seo**
Hannam University
Jayeon Lim
University of Seoul

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This study examines whether phonological memory (PM) of adult Korean learners of English correlates with their proficiency levels in L2. Previous studies have shown that PM is significantly related to L1 and L2 learning, mostly with regard to vocabulary and grammar. The present study measured PM with both English words and English-based nonwords in order to examine its relationship with L2 proficiency. Twenty Korean learners of English at different proficiency levels performed serial recognition tasks of PM words and nonwords. According to a repeated measures analysis of variance (ANOVA) and Pearson correlation, both accuracy and reaction time data revealed a significant relationship between PM words and L2 proficiency. The high group was more accurate and faster than the low group with PM words. However, no significant relationship was found between PM nonwords and L2 proficiency. The results indicate the high group learners' better performance with PM words was not replicated in PM nonwords. Additionally, the two groups exhibited different reaction times with different pair types in words, with the high group showing faster reaction time. No difference was observed with different pair types in nonwords. The findings of the present study imply that words and nonwords are differently processed by the high group L2 learners of English unlike the low group.

**[phonological memory/L2 proficiency/accuracy/reaction time/
음운기억/제 2언어 능숙도/정확도/반응시간]**

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** First author: Misun Seo, Corresponding author: Jayeon Lim

I. INTRODUCTION

Many second language (L2) studies so far have revealed effects of various factors on L2 learners' proficiency ranging from L1 transfer (Odlin, 1989, 2005), age of onset (Flege, Yeni-Komshian, & Liu, 1999; Long, 1990), to amount and types of input in L2 (Gass, 1997). While an abundant number of studies have revealed some meaningful evidence to these factors, they are far from reaching a consensus as to what constitutes L2 learning process. Most of these studies have focused on factors external to the L2 learners and also on treating these L2 learners as a group, whereas more recent studies have shifted their attention to factors that are correlated with individual differences across learners. These factors include individual differences in working memory, language aptitude, cognitive learning style, motivation and attitude (Hummel, 2009; Skehan, 2012).

During the past two decades or so, working memory capacity of L2 learners has received attention as a factor predicting individual's learning process both in L1 and L2. Working memory is a system that is used during the process of temporary maintenance of information in performing cognitive tasks (Williams, 2012). It plays various roles in speech perception, word repetition, parsing, comprehension, and learning to speak and read (Harley, 2008). Psycholinguistic studies have shown that multiple levels of knowledge compose working memory (Baddeley, 1986, 2000, 2007). It can be divided into two systems: the Central Executive and subsidiary systems. The Central Executive functions as a CPU of computer and is concerned with the control of information taken (Williams, 2012). Subsidiary systems consist of visuo-spatial sketchpad, episodic buffer and phonological memory (PM), or phonological loop.

Among the different components of working memory, PM is a system related to language proficiency (Baddeley, Gathercole, & Papagno, 1998). It is composed of two subcomponent systems: phonological store and articulatory rehearsal system. The phonological store, responsible for storing verbal information for approximately 2 seconds, is coded phonologically. The system of articulatory rehearsal allows to hold the phonological store for more than 2 seconds and to maintain memory items. Variability according to age or other individual differences may lead to different PM capacity across individuals (Skehan, 2012).

The goal of this study is to examine whether PM, measured by English words and nonwords, predicts L2 learning by adults with different proficiency levels. In the following sections, the relationships between PM and language learning as well as L2 proficiency are reviewed. In addition, after describing methods of measuring PM, research questions of the present study are provided.

1. PM and Language Learning

Different effects of PM have been well-attested in studies measuring L1 in children, mostly vocabulary abilities. A large number of studies have claimed that PM consistently correlates with vocabulary capacity of children. To a different extent, researchers varied on the nature and the basis of the relationship, but mostly agree on the connection to some extent. The correlation has been robustly found in the ability to learn new words in L1 (Baddeley et al., 1998; Gathercole & Baddeley, 1989; Gathercole, Service, Hitch, Adams, & Martin, 1999; Gathercole, Willis, Emslie, & Baddeley, 1992).

Recently, an increasing number of L2 studies have reported relationships with PM and L2 acquisition. With most of these L2 studies pointing to a close relationship with vocabulary ability and PM, a number of studies have found a positive correlation between various factors and PM. For example, the rate of vocabulary learning (Atkins & Baddeley, 1998; Cheung, 1996) as well as language background such as number of languages learners can speak and the age of onset in learning L2 was closely related to PM (Papagno & Vallar, 1995; Thorn & Gathercole, 1999). Additional studies range from showing positive relationships between PM and reading abilities (Walter, 2008) to grammatical competency (French, 2003; Kormos & Sáfár, 2008) or vocabulary abilities (Kaushanskaya, Yoo, & Van Hecke, 2011; Service & Kohonen, 1995) in L2.

2. PM and L2 Proficiency

Up to date, not many studies have specifically focused on the relationship between PM and L2 proficiency (Miettinen, 2012). O'Brien, Segalowitz, Collentine and Freed (2006) is one of the few which revealed the level of language proficiency to be related to PM. In the study where a serial nonword recognition task was provided to the L2 learners of Spanish, the participants were asked to indicate whether the nonwords they heard were identical to the previous ones. The results showed that PM was significantly correlated with vocabulary use and grammatical ability for the high level learners, but not for the low level learners.

French (2003) also found the relationship between PM and L2 proficiency with Canadian francophone children learning English in grade six. In their assessment of PM using two nonword repetition tests based on Arabic and English at two different time points (with 5-month interval), the results revealed that a close relationship existed between PM and L2 proficiency. Although PM predicted L2 proficiency in both levels, overall L2 learning during the interval of 5 months was attested only in the low proficiency levels. The results suggest that L2 proficiency levels may attest different influences of PM on the process of L2 learning.

Kormos and Sáfár (2008) showed a similar result where different level L2 learners showed different influences of PM. Specifically, no relationship between PM and L2 was found in beginner levels as opposed to pre-intermediate levels. In a comparison between beginner-level and pre-intermediate level Hungarian learners of English, no significant relationship was found between the nonword span score and proficiency for beginners, whereas some significant relationship was found between nonword span score and the pre-intermediate learners.

Overall, different studies attest different results as to the relationship between PM and L2 proficiency levels. It remains to be seen whether higher levels, lower levels or both show significant relationship with PM. It also needs to be noted that most of the previous studies have employed the method of measuring PM through nonwords.

3. Methods of Measuring PM

Previous studies have employed different methods of measuring PM. Most recent studies have favored the nonword tests as a measure of PM over earlier methods testing words, which can be influenced by familiarity of the words to be recalled. As was cited in Gathercole and Baddeley (1993), Hulme, Maughan and Brown (1991) found that familiar words showed better PM than unfamiliar words due to the availability of long-term memory. Thus, PM has been thought to be reliably measured by nonwords rather than words. In Gathercole, Pickering, Hall and Peaker (2001), it was found that the familiarity effect may be differently exerted depending on task types. In their study where memory accuracy was measured in words and nonwords by both serial recall and serial recognition tasks[1], the familiarity effect of words was realized only in the serial recall. The difference between the recognition of words and nonwords was minor.

Given the results of the previous studies, it remains controversial whether PM in either words or nonwords better predicts L2 learning. Also, it is not evident whether the familiarity effect seen with L1 users is also seen with L2 learners. With regard to L2 learners, whether the familiarity effect will interact with their differing proficiency levels remains to be investigated.

4. Goals of the Study

The present study is set out to measure the relationship between adult learners' L2 proficiency and PM. As mentioned above, the previous studies have attested mixed results

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[1] Recall method measures either spoken or written responses of learners and recognition does not require output.

as to whether there is a significant relationship between L2 proficiency levels and PM. Unlike studies with children acquiring L1, adult L2 learners at often times have spent several or more years with L2 acquisition. They have mostly reached a so-called ‘plateau’ state in their ultimate attainment of L2 (cf. Han & Odlin, 2006). For this reason, it is meaningful to measure their overall proficiency rather than to focus on an independent area of language knowledge. In the present study, TOEIC scores were used as an index of L2 learners’ overall proficiency and the relationship of PM and the two different proficiency levels (high vs. low) were examined.

Additionally, the present study is set out to measure L2 learners’ PM by employing both English words and English-based nonwords. The study intends to investigate whether L2 learners exhibit the familiarity effect of English words. The study will also include English-based nonwords in order to provide answers as to whether PM measured by English words and nonwords will equally show significant relationships with their L2 proficiency levels. In doing so, the study employs a serial order recognition test following O’Brien et al. (2006).

Finally, in the present study, reaction time as well as the accuracy of the PM tests was collected. In a number of previous studies on speech processing, reaction time has been employed as an index of difficulty. For example, Luce and Large (2001) analyzed reaction time data in order to examine the effects of probability phonotactics and neighborhood density on speech processing. In addition, in a study of the perception of Mandarin Chinese tones by Huang (2001), reaction time was measured to figure out the perceptual similarity of the two tones. Following Shepard, Kilpatrick and Cunningham (1975), it was assumed that it will take longer to notice the difference of two similar things, compared with the difference of two different things. Thus, in her study, reaction time was used as a measure of difficulty in a discrimination task. In line with such previous studies, in the present study, reaction time was collected from the PM tests to see subjects’ processing rates. The following research questions will be verified:

1) What is the relationship of L2 proficiency level and PM of words and nonwords, measured by accuracy?
2) What is the relationship of L2 proficiency level and PM of words and nonwords, measured by reaction time?

II. METHODS

1. Participants

Tests measuring PM were conducted with 20 Korean learners of English. They were recruited from two different universities in Korea. Of the participants, 10 (five males and five females) were low in English proficiency with TOEIC scores in the 500s. The other 10 (five males and five females) were high in English proficiency with TOEIC scores in the 900s. All of the participants were in their 20s and paid for their participation in the tests.

2. Stimuli

Two serial order recognition tests, one with English words and the other with English-based nonwords, were conducted to measure each participant's PM. In the two tests, the participants were asked to judge whether or not the second presentation of a list of items was the same (same trials) or different (different trials) from the first presentation. Items used in the tests were one-syllable English words or English-based nonwords consisting of an onset consonant followed by a vowel and a coda consonant. The items were modified from the list of Gathercole et al. (2001).

In each of the two tests, there were eight lists of items at each of four list lengths: four, five, six and seven. Of the eight lists for each of the list lengths, four were same trials and the other four were different trials. Thus, each participant was tested with 32 lists of English word items for the word serial order recognition task and with another 32 lists of English-based nonword items for the nonword serial recognition task. In constructing a list of items within each list length, vowel sounds in the same list were different from each other. In the same vein, consonants were as phonologically distinct as possible from each other. Different trials were made in such a manner that two adjacent items in the middle of each list were transposed in the second presentation of each list. That is, on different trials, the first and the last items were never transposed with their adjacent items. The location of the transposed items was varied across lists and eight lists of items at each list length were randomly presented to each participant. An example of a same trial at the sequence length of four in the word serial recognition task is '*bid, can, juice, numb*, … *bid, can, juice, numb'*. An example of a different trial at the sequence length of four in the nonword serial recognition task is '[pɑtʃ], [tɪg], [nʌb], [gu:k], … [pɑtʃ], [nʌb], [tɪg], [gu:k]'. A full list of trials in the two tasks is presented in Appendix. Four lists (two same trials and two different trials) of a three-item length were additionally constructed for a practice trial both in word and nonword tests. English word and nonword items were recorded in a quiet room by a native English speaker, a male in his 30s from Canada.

3. Procedure

The participants were tested individually in a quiet room using the E-prime program installed on a computer. The E-prime is a software frequently used for perception experiments and it can measure reaction time as well as accuracy. After completing the three-item practice trials, the participants were presented with eight four-item lists followed by eight five-item lists, eight six-item lists and finally eight seven-item lists. The presentation order of the two tasks (i.e., the word and nonword serial order recognition tasks) was counterbalanced within each participant group. Thus, 5 low and 5 high group participants completed the word task before the nonword task and the rest of the participants did in the opposite order.

In auditorily presenting stimuli through headphones, there was an interval of 750 ms between each items and an interval of 1.5 s between the first and second presentation of each list that made up a given trial. For example, when presenting the four-item same trial '*bid, can, juice, numb*', each item was presented with an interval of 750 ms and after an interval of 1.5 s each item was presented again in the same order with an interval of 750 ms. The participants were asked to respond by pressing the 'same' or 'different' key. They were instructed to press the 'same' key if they think the second presentation of the items was presented in the same order as the first presentation and the 'different' key if the second presentation of the items was presented in an order different from the first presentation. The participants were asked to respond as accurately and quickly as possible. From the tests, the accuracy and reaction time data were obtained and analyzed in terms of a repeated measures analysis of variance (ANOVA) and Pearson correlation.

III. RESULTS

1. Accuracy

To analyze the accuracy data from the word and nonword serial order recognition tests, following O'Brien, Segalowitz, Freed and Collentine (2007), a weighted score was first computed. That is, to reflect the greater difficulty with longer sequence length, correct responses at sequence length 4 were assigned a score of 4, those at sequence length 5 a score of 5, those at sequence length 6 a score of 6 and those at sequence length 7 a score of 7. The maximum weighted score was 176 in each of the two serial order recognition tests.

A repeated measures analysis of variance (ANOVA) was run with the weighted accuracy scores as a dependent variable. In the analysis, participants' proficiency (low vs. high) was a between-subject factor and a stimulus type (word stimuli vs. nonword stimuli) and a pair type (same trials vs. different trials) were within-subject factors. According to the analysis, there was a significant main effect of proficiency ($F(1, 318) = 12.436$, $p < .05$). Out of the mean maximum weighted score of 5.5, the high group exhibited a mean weighted score at 4.14 and the low group at 3.61. On the other hand, there were no significant main effects with a stimulus type ($F(1, 318) = .731$, $p = .388$) and a pair type ($F(1, 318) = 1.198$, $p = .274$). In addition, a marginally significant interaction was observed with proficiency * stimulus type ($F(1, 318) = 3.274$, $p = .071$). Figure 1 illustrates the finding.

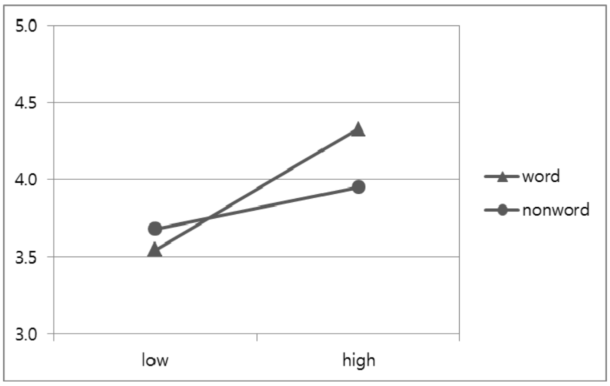

Figure 1 Mean Weighted Accuracy for Proficiency * Stimulus Type

As can be seen from Figure 1, the low and high groups showed an opposite trend for the word and nonword serial order recognition tests. While the low group illustrated a higher mean weighted accuracy score at the nonword test (3.68) than at the word test (3.55), a reversed pattern was attested with the high group (4.33 for the word test and 3.96 for the nonword test). This tendency is more clearly revealed when looking at each participant's word vs. nonword scores in the two groups. The scatterplots in Figure 2 illustrate the participants' mean weighted accuracy of the word and nonword tests in the low and high groups. In the scatterplots, the horizontal axis represents the mean weighted accuracy of the word test and the vertical axis that of the nonword test.

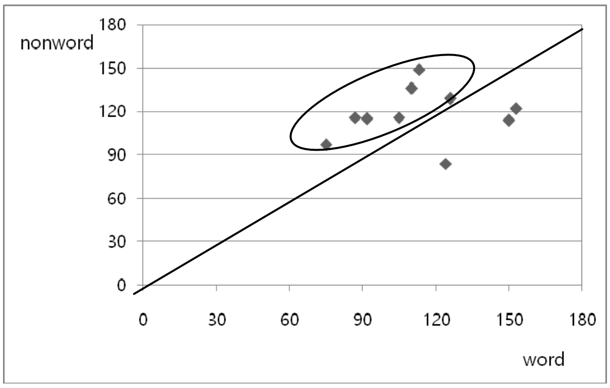

Figure 2-1 Mean Weighted Accuracy, Low Group

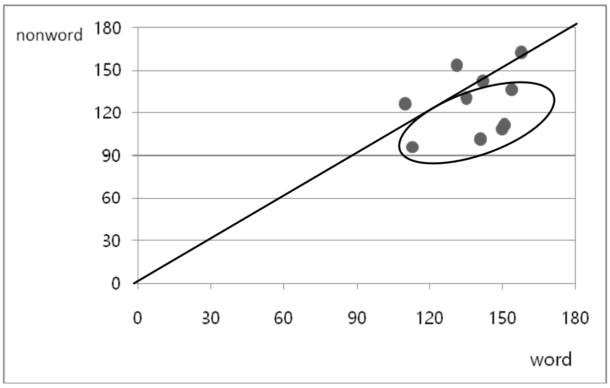

Figure 2-2 Mean Weighted Accuracy, High Group

As can be seen from Figure 2-1, 7 out of the 10 low group subjects exhibited higher mean weighted accuracy for the nonword test than for the word test. On the other hand, an opposite pattern is found in the high group. As shown in Figure 2-2, higher mean weighted accuracy was found for the word test than for the nonword test in 6 out of the 10 high group subjects.

In order to examine the relationships between proficiency and mean weighted accuracy in the word and nonword serial order recognition tests, Pearson correlation coefficients were calculated. Table 1 illustrates the result.

TABLE 1

Pearson Correlation Coefficients: Accuracy

	Proficiency	Word scores	Nonword scores
Proficiency	1		
Word scores	.154*	1	
Nonword scores	.052	.058	1

* $p < .05$

As can be seen from Table 1, proficiency and the scores of the word recognition test were significantly correlated with each other ($p < .05$). On the other hand, there was no significant correlation between proficiency and the scores of the nonword test.

2. Reaction Time

In analyzing the reaction time data, incorrect responses were excluded. In addition, to avoid the influence of outliers on the results, following Duffield and White (1999), all responses falling outside of a cut-off point of above and below two standard deviations of a particular participant's personal mean were corrected to the corresponding cut-off value. For each of the cases in which a participant gave no correct response, reaction time was filled in by an expected value obtained by the addition of a mean deviation for each of the 32 list types (8 list types at each of the 4-, 5-, 6-, and 7- item length) and a mean of the particular participant's reaction time. The mean deviation for each of the list types was calculated by subtracting the list type mean from the total mean.

As previously mentioned, the reaction time data were collected with the E-prime program. For the reaction time, the program was set to measure the time between the onset of the second presentation of the items and the point that a participant pressed the response button. With this setting, the reaction time increases in proportion to the sequence length of a stimulus. Thus, the time during which the second presentation of the items lasted was subtracted from the reaction time obtained from the E-prime. In this method, the reaction time ranges from a negative to a positive value. A negative value is obtained when a participant presses the response button before the second presentation of the items is completed. If the response button is pressed after the second presentation of the items, a positive value of the reaction time is obtained.

A repeated measures analysis of variance (ANOVA) was conducted with reaction time as a dependent variable. In the analysis, participants' proficiency (low vs. high) was a between-subject factor and a stimulus type (word stimuli vs. nonword stimuli) and a pair type (same trials vs. different trials) were within-subject factors. According to the analysis, there was a main effect of proficiency ($F(1, 318) = 5.356$, $p < .05$). The high group exhibited significantly faster reaction time at −750.5 ms than the low group at −552.9 ms.

In addition, significant main effects were also found with a stimulus type ($F(1, 318) = 7.221$, $p < .05$) and a pair type ($F(1, 318) = 175.232$, $p < .05$). The subjects' mean reaction time was significantly faster with the word stimuli at −771.5 ms than with the nonword stimuli at −531.8 ms. Mean reaction time was also significantly faster with the different stimuli at −1129.9 ms than with the same stimuli at −173.4 ms.

A significant interaction was attested with proficiency * pair type ($F(1, 318) = 6.127$, $p < .05$). Figure 3 illustrates the finding.

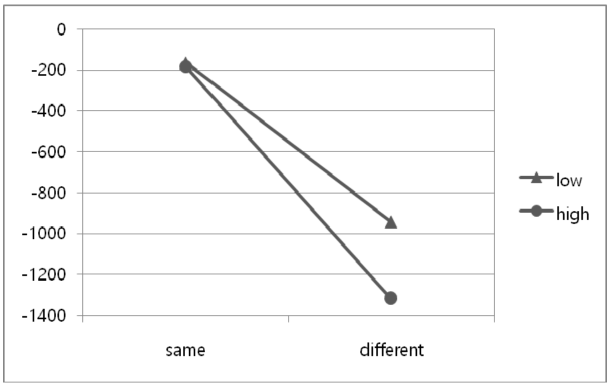

Figure 3 Mean Reaction Time for Proficiency * Pair Type

As can be seen from Figure 3, with the different trials, the high group exhibited significantly faster mean reaction time at −1318.1 ms than the low group at −941.7 ms ($t(638) = 2.651$, $p < .05$). On the other hand, the two groups' mean reaction times were not significantly different with the same trials (−164.1 ms for the low group and −182.8 ms for the high group). Pearson correlation coefficients were computed to examine the relationships between proficiency and reaction time in the same or different trials. It was found that proficiency and reaction time in the different trials were significantly correlated with each other at −.104 ($p < .05$) while proficiency and reaction time in the same trials were not significant at −.010.

There was a significant interaction with stimulus type * proficiency * pair type ($F(1, 318) = 5.209$, $p < .05$). The finding is shown in Figure 4.

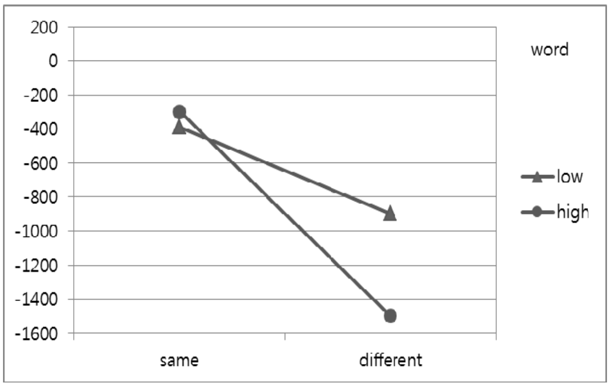

Figure 4-1 Mean Reaction Time for Proficiency * Pair Type, Word

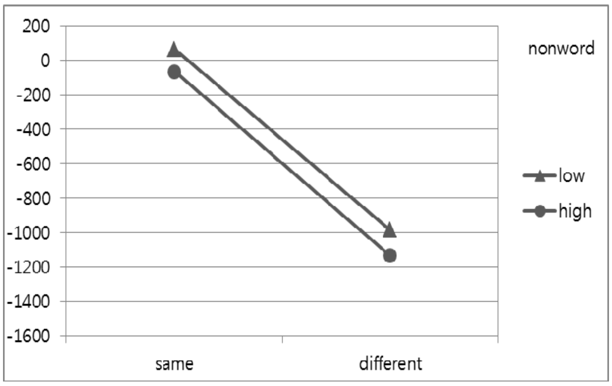

Figure 4-2 Mean Reaction Time for Proficiency * Pair Type, Nonword

Figure 4-1 represents the result of proficiency * pair type in the word test and Figure 4-2 the one in the nonword test. From the figures, it can be seen that a great reaction time difference between the two groups occurred in the different trials of the word test: the high group showed much faster reaction time at −1500.4 ms than the low group at −897.5 ms. According to a *t*-test, the difference was significant ($t(318) = 2.842$, $p < .05$). In addition, according to the computation of Pearson correlation coefficients, proficiency and reaction time in the different trials of the word test were significantly correlated with each other at −.157 ($p < .05$). On the other hand, a series of *t*-tests revealed that the reaction time differences between the two groups in the rest of the three conditions were not significant.

IV. DISCUSSION AND CONCLUSION

Results of the accuracy revealed a significant main effect of proficiency: the high group showed higher accuracy than the low group. That is, learners with higher proficiency exhibited higher PM scores than those with lower proficiency. Further, a marginally significant interaction was attested with proficiency and stimulus type. Specifically, the low group showed similar accuracy for both word and nonword tests, whereas the high group exhibited higher accuracy with the word test over the nonword. That is, proficiency level of L2 learners was related to the stimulus type of PM test measured by accuracy. Interestingly, no significant relationship was found between proficiency level and the accuracy of the nonword PM test. The finding is contradictory to the previous studies where nonword PM was revealed to be a meaningful factor for language learning (Gathercole & Baddeley, 1993; Hulme et al., 1991; Kormos & Sáfár, 2008).

In the present study, where a comparison was made between word and nonword PM tests, word PM was found to be related to L2 proficiency. Since word PM stimuli were based on English words, higher level learners were expected to perform better. Previous studies have attested word PM to be more likely influenced by learners' proficiency level due to familiarity effect (Gathercole & Baddeley, 1993; Hulme et al., 1991). The present study is in line with the finding.

According to the previous studies, due to lack of familiarity effect, nonword PM has been considered a reliable predictor for L1 and L2 learning in terms of vocabulary, grammatical development and language proficiency (French, 2003; Gathercole & Baddeley, 1993; Hulme et al., 1991; O'Brien et al., 2006). In the present study, unlike previous studies, nonword PM did not have a significant relationship with L2 proficiency for adult learners. The high and low groups did not show a significant difference with nonword PM. The high group, despite their higher proficiency and presumably higher level of existing L2 knowledge, failed to extend this knowledge to novel sound sequences of nonword PM. Since nonwords in the present study were created based on English words, the high group was expected to show better performance with nonword PM due to their familiarity with sound structures in English.

The results of the present study indicate that being familiar with actual instances of L2 words and thus showing better performance with nonword PM are independent of having access to L2 sound structures. One of the controversial issues in L2 studies has been whether learners first have access to structures or rules and then later apply these to actual instances, or need to be exposed to ample amount of actual instances to be able to learn structures or rules (Williams & Lovatt, 2005). At least in the present study, the results suggest that the high group learners show learning of actual instances without being able to extend this learning to new instances. However, what needs to be noted is that the high group learners in the present study are not at the level of near-natives or bilinguals with equal proficiency in L1 and L2. Thus, whether these learners will eventually reach the stage where they will be able to apply the knowledge of actual instances to acquire the L2 sound structures remains to be examined.

Results of the reaction time revealed a significant main effect of proficiency, as with accuracy: the high group performed faster than the low group. That is, learners with higher proficiency exhibited faster processing of PM than those with lower proficiency. The high group adult L2 learners in the present study were more accurate and also faster than the low group in processing PM. Thus, PM, measured by accuracy and reaction time is positively related to overall proficiency in L2.

A significant interaction was attested with proficiency and pair type in the reaction time data. Specifically, the high and low groups were similar in reaction time in cases where two sequence items were presented in the same order. However, the high group performed faster than the low group in cases where two sequence items were presented in a different order. With the same trials, participants would have to wait until the second from the last item was presented when responding. However, with the different trials, participants can respond as soon as they notice the difference between the two sequences. Thus, faster performance of the high group in the different trials implies that they are showing more efficient processing of PM.

Additionally, the high group was faster with the different trials in word PM than the low group. There was no difference between the two groups with the different stimuli in the nonword PM. As with the accuracy, familiarity effect was at play with higher level learners since they seem to have applied their existing L2 knowledge to relatively familiar stimuli of word PM, thus speeding up their processing. Again, they seem to be unsuccessful in extending this knowledge in processing nonwords.

The present study observed that PM, measured by English words, was related to L2 proficiency of adult Korean learners. The high group learners showed higher accuracy and faster reaction time than the low group learners. When the accuracy of the two groups were similar (i.e., different pair types in word stimuli), their reaction times were different. Thus, the high group's faster reaction time indicates more efficient processing is at hand than the low group. However, the high group showed much slower reaction time with different pair types in nonword stimuli. This indicates that the high group learners were not able to exhibit similar processing rates in different pair types of words and nonwords. In a sense, with the high group learners, independent processing is examined in words and nonwords. Therefore, what they have acquired in words does not extend to nonwords.

The present study provides a meaningful addition to the role of PM in L2 learning by adding results from reaction time data along with accuracy of L2 learners with different proficiency levels. Even in cases when the L2 learners with different proficiency levels do not show differences in accuracy, their reaction times indicate different processing rates can be found in two different groups of learners.

The results of the present study may provide some pedagogical insights to teachers and students of L2 in classrooms. As was presented, proficiency levels of L2 learners at least partially correlate with PM in L2. Thus, PM may seem to interact with overall command of L2. It is not clear at present whether PM is related to language aptitude or language learning ability in general, since language learning ability is a complex one (Miyang Cha & Narang, 2008). Thus, both teachers and students need to note that different levels of linguistic knowledge (i.e., phonology, lexicon, syntax, etc.) may not be completely independent of each other. Future studies need to investigate the exact nature of PM so as to find its connection to overall linguistic proficiency of L2 learners.

This study is not without limitations. As was mentioned previously, the high group learners in the present study are not at the level of near-natives. It is not clear whether they have reached an end-state in their L2 learning or still in the course of L2 development. To complement the results of the present study, additional data need to be collected from bilinguals with comparable proficiency in both L1 and L2. Finally, a larger sample of learners, with their proficiency scores measured by a variety of modes including productive skills, would provide more insightful analysis regarding the research questions.

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APPENDIX

The Words Used in the Serial Recognition Task

Four-item lists	bid, can, juice, numb
	cheap, dumb, pet, lock
	sock, cat, mush, bin
	peach, mad, set, goof
	mud, pick, nap, shoot
	tap, could, but, mill
	soup, gun, tick, pad
	gap, tin, shock, said
Five-item lists	bag, ditch, pot, cool, mug
	much, boot, league, neck, jog
	luck, map, shot, chin, boss
	deep, beg, nod, jack, moot
	gum, dot, lap, meek, pull
	lad, seat, cough, pock, moon
	bit, peg, dodge, mood, knuck
	badge, mean, duck, knob, push
Six-item lists	catch, got, dim, bug, tool, keen
	big, chop, net, muck, jab, soon
	loot, bed, palm, jean, mash, chick
	mock, pat, beach, ten, lid, coop
	jeep, mob, chat, shook, bell, come
	beam, check, top, dawn, suit, cab
	pod, tan, chip, boom, caught, deck
	bead, pen, jot, moose, talk, dig
Seven-item lists	calm, chap, jig, lawn, book, tough, dell
	walk, put, lead, gem, nag, job, touch
	meet, leg, sad, loop, chalk, god, bun
	batch, cop, gym, done, pool, log, geese
	mesh, lot, nip, buff, took, cog, jam
	bean, jet, mop, look, dog, laugh, doom
	chuck, lop, June, dull, good, neat, lamb
	teach, dam, knock, pin, bought, gel, cup

The Nonwords Used in the Serial Recognition Task

Four-item lists	[bɑk, tʃæl, gɪp, dʒʌm]
	[kɔn, lug, mitʃ, tɛp]
	[nɛg, pʌtʃ, dæl, bɔf]
	[dʒig, lʌb, kɔp, tɛm]
	[pɑtʃ, tɪg, nʌb, guk]
	[kɪb, dʌdʒ, putʃ, gɛf]
	[mʌv, lɛn, pɪd, tʃus]
	[pɪb, tæm, gutʃ, dʌf]
Five-item lists	[tɛg, bɑn, dʌp, kum, nif]
	[chum, kɛp, lɔk, nʌg, gɪt]
	[pim, tɑg, gæb, tʃɛl, mɪp]
	[gut, nal, bɛm, dʒɪp, mɔn]
	[lub, dʒɑl, mɛb, ditʃ, kɛm]
	[kitʃ, dʒɔd, mɛp, tug, bɪk]
	[kim, tɔd, mɑdʒ, dʒʌtʃ, gɛk]
	[lɑf, tɛdʒ, bæl, nʌd, gɑm]

Six-item lists	[bɑdʒ, tʃuf, mɪg, dæk, kɛb, lɔm]
	[tudʒ, dʒʌp, lɛk, nɔd, tʃɪm, pib]
	[pɑn, mæb, dudʒ, nig, tʃɛm, tɪd]
	[budʒ, tʌd, lɪg, pæb, dʌt, gɛl]
	[tɪdʒ, mʌp, tʃɛn, gʌb, nug, dit]
	[tɔm, pæg, dʒɪk, dɛp, kɑl, bʌp]
	[kib, tɑk, næl, pɪm, dʒɛg, tʃʌp]
	[pædʒ, nɛp, mɑn, tʃʌt, gub, tid]
Seven-item lists	[tʌdʒ, bɪf, nul, gid, tʃɛp, pɑg, dʒɛk]
	[duk, tʃæd, lɪdʒ, gɔp, dʒɛp, mɑt, bʌv]
	[gɑk, nʌtʃ, mɔd, tʃæm, lʌf, tip, bɛs]
	[tɑb, gæn, dɑtʃ, tʃul, dʒʌk, nɔg, pɛm]
	[nɪg, gædʒ, mʌn, puk, tib, lɔf, tʃʌd]
	[nɔp, lʌd, pɑk, tʃiv, dub, dʒæt, kɪg]
	[lɪm, kʌg, tʃudʒ, dʒʌt, kɛd, dɑp, gib]
	[tʃɪg, næm, pɛb, gɑp, dʒutʃ, lɔd, tɪv]

Examples in: English
Applicable Languages: English
Applicable Levels: Tertiary

Misun Seo
Department of English Language and Literature
Hannam University
70 Hannam-ro, Daeduk-gu,
Daejeon, 306-791, Korea
Tel: (042) 629-8461
E-mail: misunseo@hnu.kr

Jayeon Lim
Department of English Language and Literature
University of Seoul
90 Siripdae-gil, Dongdaemun-gu,
Seoul, 130-743, Korea
Tel: (02) 6490-2521
E-mail: limjy@uos.ac.kr

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