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# Research Forum

## Reexamination of Word Length Effect: Immediate Serial Recall of Foreign Words

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In this study we examined the word length effect—one characteristic of the phonological loop of working memory—in a foreign language. Serial position effects, such as the primacy effect and the recency effect, were observed in the recall of foreign words, similar to results in L1 studies. Recall of long (one-syllable) and short (three-syllable) words in pure (all long or all short) and mixed (long and short) lists was compared. In pure lists, there was a tendency for long words to be more poorly remembered than short words, which we considered to be because of the word length effect. In mixed lists, both long and short words were recalled equally as well as short words were recalled in pure lists. These results indicate that we should pay more attention to item distinctiveness, which elicits the attention of the central executive in working memory, as well as the word length effect in regards to rehearsal speed. Effective use of the phonological loop in listening comprehension is also discussed.

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本研究は、ワーキングメモリモデルの音韻ループに見られる語長効果について再検討を試みたものである。外国語の単語記銘においても、母国語話者を対象とした研究と同じように初頭効果や新近性効果が確認された。単純リストと混合リストにおける長い語と短い語の再生率を比較したところ、単純リストでは、長い語は短い語よりも再生率が悪くなるという語長効果の傾向が見られるものの、混合リストにおいては、長い語も短い語も単純リストにおける短い語と同程度の再生率であった。これらの結果は、短期記憶容量は決められた項目数ではなく復唱速度が重要な要因であるという語長効果に基づく説明に加えて、ワーキングメモリの中央実行系に注意喚起を促す、項目の示差性などによる説明の必要性があることを示している。本研究では、聴解における音韻ループの効果的な活用についても論じている。

In listening, information is conveyed by speech sounds that gradually decay in memory over time. In the process of listening comprehension learners must store the incoming information in short-term memory while they are trying to analyze it. A variety of cognitive processes function interactively in foreign language listening. The processes include temporal storage of the incoming sound, the matching of prosodic features with the phonological database in prior knowledge, syntactic analysis, and semantic analysis. In the past few decades, working memory as conceived by Baddeley and Hitch (1974) and refined by Baddeley (1986, 2000, 2012) has been discussed in terms of information storing and processing. Working memory is considered to be a system that provides temporary storage and allows for active manipulation or processing of the information necessary for complex cognitive tasks such as language comprehension, learning, and reasoning. We must take working memory into consideration when listening comprehension is discussed theoretically.

One of the components of the working memory model is the phonological loop. It is considered the main component in analyzing speech input and is believed to play an important role in listening comprehension. The loop is assumed to hold verbal material in a limited-capacity phonological buffer in which traces decay relatively rapidly but may be refreshed by subvocal articulation (Baddeley, Gathercole, & Papagno, 1998; Gathercole & Baddeley, 1993). It should be noted that the input is being subvocally rehearsed not only when listening to one's native language but also when listening to a foreign language. The key to understanding the capacity of the phonological loop is that it has a time constraint.

An early qualification of the capacity limit associated with short-term memory was "the magical number seven plus or minus two" introduced by Miller (1956, p. 81). He suggested that the memory span of young adults was about seven items, called chunks, regardless of whether the items were random lists of letters, words, numbers, or almost any kind of meaningful

familiar item. Among cognitive psychologists, memory span was generally thought to be about seven digits, six letters, or five words.

On the other hand, some studies have found that the capacity of the loop is not limited by a fixed number of verbal items, but rather by how much a listener can pronounce in approximately 2 seconds (e.g., Baddeley, Thomson, & Buchanan, 1975). Schweickert and Boruff (1986) proposed that memory span does not depend on a *magic number* but rather on a *magic spell*, which refers to the ease with which a word can be pronounced, which in turn depends upon the complexity of its spelling. This means that memory span is greater for items that can be pronounced more easily. These studies helped to explain why memory span is different to a certain degree for such dissimilar items as digits, letters, or words. In other words, the size of memory span for verbal items is dependent on the time it takes to articulate them and on subvocal rehearsal speed.

Baddeley et al. (1975) found evidence that memory span is time based. They explored the relationship between word length and memory span. Their findings indicated that memory span decreased as the number of syllables in a word increased. Baddeley (1999) noted that "longer words are more difficult to recall because they take longer to articulate during rehearsal" (p. 52). This effect is called the word length effect. It should be noted here that although the effect is called the word length effect, the temporal duration of a word might also determine memory span when the number of syllables and the number of phonemes are constant (Baddeley et al., 1975).

Contrary to the findings of the above studies, Hulme, Surprenant, Bireta, Stuart, and Neath's (2004) unexpected results challenged previous influential research on the word length effect on short-term memory. In their study, pure lists of one-syllable (short) words, pure lists of five-syllable (long) words, alternating lists that began with a short word, and alternating lists that began with a long word were presented to native speakers of English. The data showed a large disadvantage for the recall of pure lists of long words. However, the level of recall of words in the other three lists was similar. The results contradict the model that explains the word length effect in terms of what are termed list-based accounts of rehearsal speed, also sometimes referred to as the globalist assumption (Cowan, Baddeley, Elliot, & Norris, 2003). The globalist assumption focuses on recall of each list rather than on each item. According to these explanations, the recall of alternating lists should be worse than that of pure short lists. Alternating lists contain long words and it takes longer to rehearse them. In the phonological loop model, the greater the number of long words there are, the

fewer the number of words that can be rehearsed in a time-limited loop (Baddeley, 1986). In the slightly different list-based account by Cowan et al. (1992), rehearsal of a long word in the list delays the rehearsal and recall of other words in the list. As a result, long words in the list are allowed to decay more than short words in the list.

Hulme et al.'s (2004) comparison of the recall of long and short words in pure and alternating lists also contradicts the model that explains the word length effect in terms of item-based effects such as difficulty in assembling items. The item-based account is also referred to as the localist assumption (Cowan et al., 2003), which focuses on recall of each item rather than on each list. Hulme et al. argued that the word length effect was essentially a word complexity effect and item distinctiveness played a critical role in retrieval. They asserted that longer words are more complex than shorter words and that short words and long words are distinct from each other in alternating lists.

The word length effect explains that memory span has a time constraint and speed of rehearsal is important. Cowan and Kail (1996) placed more emphasis on the rehearsal speed. As they pointed out, processing speed and subvocal rehearsal speed greatly affect learners' memory spans. An increase in memory span facilitates listening comprehension, and processing speed increases subvocal rehearsal speed. In summary, memory span—the capacity of the phonological loop—is determined by how fast listeners can repeat verbal input.

Some studies have focused on the pedagogical effects of repetition practice and shadowing practice on EFL listening. For example, Futatsuya and Kaneshige (2001), Takeno (2010), and Tamai (2005) researched the relationship between listening comprehension and the effective use of the phonological loop capacity. Repetition practice places importance on repeating the speech input as accurately as possible immediately after the input is heard while retaining it in the phonological loop. Conversely, shadowing practice puts emphasis on repeating the speech input as accurately as possible while listening to it. Both practices should be considered important in that they can accelerate rehearsal speed and improve bottom-up processing during the process of listening comprehension. These studies were based on the concept of the phonological loop of working memory. The word length effect is one part of the cluster of evidence that supports the phonological loop.

The word length effect has been indispensable to the development of theories of performance in immediate serial recall. In immediate serial recall, the first and last items in the series tend to be recalled best and the middle

items worst. The greater likelihood of a person to recall the first few items than the middle items is known as the primacy effect; the greater likelihood of recall of the last few items is termed the recency effect. It would be highly problematic if the word length effect, which has played a crucial role in explaining the importance of rehearsal speed, were inaccurate. The research reviewed above shows that immediate serial recall has been investigated with different research designs with native speakers, but very little research, if any, has been conducted with Japanese learners of English on the word length effect in recalling foreign words. The present study was conducted to explore this effect. An examination of the influence of item distinctiveness on recall will help inform both pedagogical decisions and future research on immediate serial recall of foreign words.

## Research Questions

Based on the above discussion, three research questions were formulated.

RQ1. To what extent are the serial position effects, such as the primacy effect and the recency effect, observed in the recall of foreign words compared with those in L1 research?

RQ2. When comparing the recall of pure lists of short words, pure lists of long words, alternating lists that begin with a short word, and alternating lists that begin with a long word, to what extent do list-based accounts of the word length effect explain the result?

RQ3. When comparing the recall of long and short words in pure and alternating lists, to what extent do item-based accounts of the word length effect explain the result?

## Method

In order to confirm that the word length effect had an impact on immediate serial recall of foreign words, our procedure roughly corresponded to Experiment 1 of Hulme et al. (2004), though with some important differences in participants, instruments, design, and procedure, as explained below.

### *Participants*

Seven female and three male 3rd-year undergraduates majoring in EFL volunteered to participate in this research. Their English levels ranged from upper intermediate to advanced. All participants were native speakers of Japanese.

### *Instruments*

Two sets of words were used, one set of three-syllable words and one set of one-syllable words. Each set comprised eight words. The set of three-syllable words was *gorilla, stomachache, library, Mexico, radio, history, magazine,* and *calcium;* the set of one-syllable words was *horse, flu, school, France, switch, art, book,* and *gold*. Each set contained one word from each of eight semantic categories: animals, diseases, education, countries, electronics, subjects, literature, and chemistry. The items from each category were matched as closely as possible for familiarity to the participants, for example, animals (*gorilla* / *horse*) and countries (*Mexico* / *France*). The words used are a subset of the words used in Baddeley et al. (1975) as was the case with Hulme et al. (2004), except that difficult words from the previous studies were replaced so all the participants in the present study could be expected to know them. Hulme et al. (2004) used five-syllable words for long words and one-syllable words for short words. However, in the present study we used three-syllable words for long words and one-syllable words for short words because, based on our collective teaching experience, we judged lists of five-syllable words to be too difficult for these participants to recall even though their English proficiency was above average for Japanese learners of English. The five-syllable words included in the original pools of words by Baddeley et al. (1975) were *hippopotamus, tuberculosis, university, Yugoslavia, refrigerator, physiology, periodical,* and *aluminium.*

A total of 24 sequences were generated, equal numbers of four types of lists: pure lists of one-syllable words (*pure short*), pure lists of three-syllable words (*pure long*), alternating lists that began with a short word (*SLSLSL*), and alternating lists that began with a long word (*LSLSLS*). Six sequences were constructed for each of the four list types according to the following constraints: (a) pure short lists were made from the set of one-syllable words, (b) pure long lists were made from the set of three-syllable words, and (c) alternating lists were constructed by sampling from each of the two sets. Six items were randomly selected for each sequence from one or both of the eight-item sets. The words in each sequence were arranged in random order (see Appendix). A male native speaker of American English recorded all sequences, and items in each sequence were spoken at a rate of one item per second.

### *Design and Procedure*

The research was conducted in the language laboratory at a university in Japan. In order to familiarize participants with the two sets of words used in this study, participants were given a sheet of the words and asked to listen to

the 16 words successively through a headset. If paricipants were uncertain of their understanding of a word, the teacher gave an explanation of the word, and the word was pronounced again.

Participants were tested on a series of 24 sequences. After each sequence was spoken, the participants were asked to recall the sequence and write down the words in the order of presentation. A response was counted as correct if it was the correct word recalled in the appropriate position.

## Results and Discussion

Assessments of immediate serial recall of foreign words were made for the 10 participants, based on their correct recall of each word in the appropriate position. The data were analyzed and the results and discussion of each of the three research questions are presented below.

### *Research Question 1*

To what extent are the serial position effects observed in the recall of foreign words compared with those in L1 research? Table 1 shows the mean percentage of words correctly recalled in the appropriate position as a function of list type and serial position. The mean percentage of each list type is expressed at the right end of the table vertically. The mean percentage of each serial position is expressed at the bottom of the table horizontally and is plotted in Figure 1.

Table 1. Mean Percentage of Words Correctly Recalled in the Appropriate Position as a Function of List Type and Serial Position ($N = 10$)

| | Serial position | | | | | | |
|---|---|---|---|---|---|---|---|
| List type | 1 | 2 | 3 | 4 | 5 | 6 | Mean |
| Pure short | 98.3 | 83.3 | 61.7 | 51.7 | 21.7 | 6.7 | 53.9 |
| Pure long | 88.3 | 75.0 | 53.3 | 30.0 | 6.7 | 18.3 | 45.3 |
| SLSLSL | 91.7 | 85.0 | 61.7 | 46.7 | 25.0 | 28.3 | 56.4 |
| LSLSLS | 96.7 | 78.3 | 70.0 | 46.7 | 23.3 | 26.7 | 56.9 |
| Mean | 93.8 | 80.4 | 61.7 | 43.8 | 19.2 | 20.0 | |

*Note.* SLSLSL = alternating lists that began with a short word; LSLSLS = alternating lists that began with a long word.

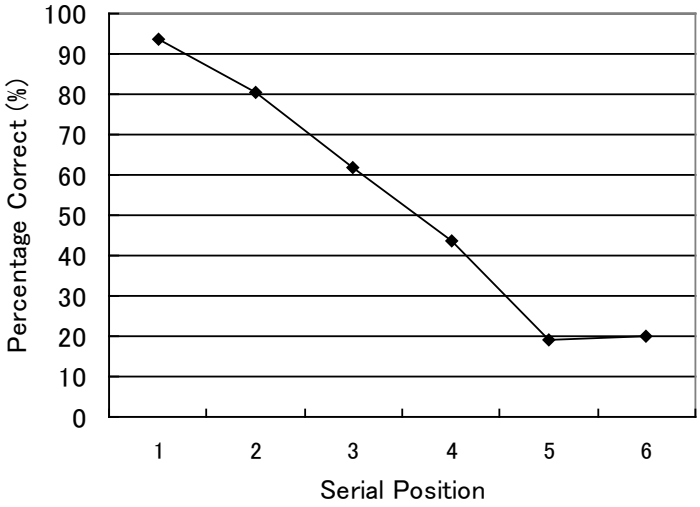


*Figure 1.* Mean percentage of words correctly recalled in the appropriate position as a function of serial position.

A one-way factorial analysis of variance (ANOVA) on the mean percentage of words correctly recalled as a function of serial position showed a significant effect, $F(5, 18) = 66.40$, $p < .01$, $\eta_p^2 = .95$. A post hoc test adjusted for Bonferroni confirmed that there was a statistically significant effect for serial positions 2 - 3 ($p < .05$), and 4 - 5 ($p < .01$), but not for positions 1 - 2, 3 - 4, and 5 - 6.

The data in Table 1 and Figure 1 indicate that the first serial position had the highest percentage of correct recall and that the correct recall percentage decreased as serial position increased. From this result, the primacy effect was observed in the recall of foreign words. Moreover, the correct recall percentages for serial positions 5 and 6 were at similar levels. The decrease of correct recall stopped at serial position 5, suggesting that the recency effect played some part in recalling foreign words.

Our results are similar to those of Hulme et al. (2004), although that study was not focused on the serial position effect. The serial position effects, such as the primacy effect and the recency effect, are observed in the recall of foreign words, similar to the results of L1 studies.

### *Research Question 2*

To what extent do list-based accounts of the word length effect explain the recall of pure lists of short words, pure lists of long words, alternating lists that begin with a short word, and alternating lists that begin with a long word? The data from Table 1 are graphically shown in Figure 2. The mean percentage of words correctly recalled in the appropriate position as a function of list type appears in Figure 3.

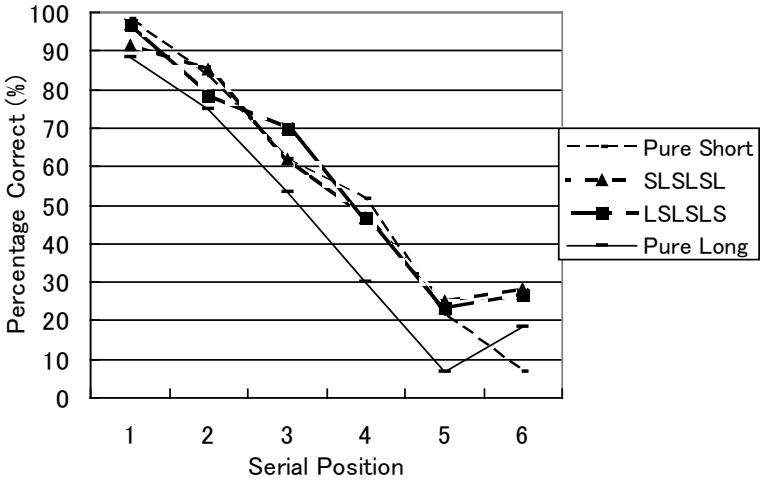


*Figure 2.* Mean percentage of words correctly recalled in the appropriate position as a function of list type and serial position.

Participants appeared to have difficulty recalling pure lists of long words. It seemed clear that the degree of recall of words in the other three lists was at a similar level to that in Hulme et al. (2004). Hulme et al. asserted that alternating lists are approximately as easy to recall as pure short lists because within each sequence the words are distinctly different in length. We agree with their explanation, although word complexity and familiarity may also be factors. In order to confirm this, comparisons were made of the mean percentage of words correctly recalled in the appropriate position as a function of list type in an ANOVA. The ANOVA yielded no significant difference, $F(3, 20) = .177$, $p > .10$, $\eta_p^2 = .03$. Hulme et al. found a large advantage for the recall of pure lists of short words against long words. In the present study, however, the word length effect was not observed in list-based accounts.

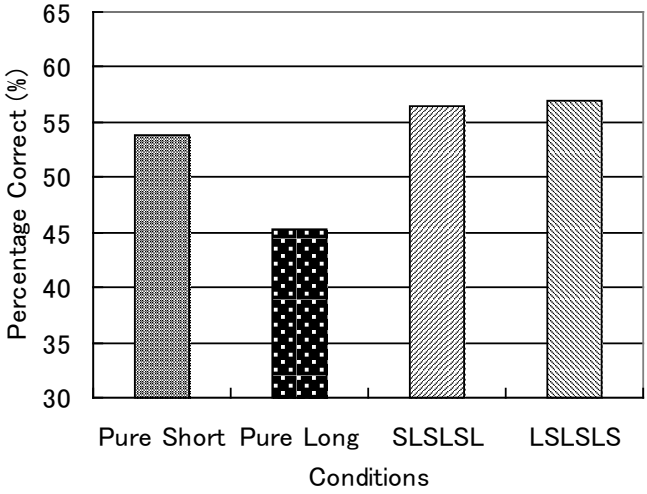


*Figure 3.* Mean percentage of words correctly recalled in the appropriate position as a function of list type.

The absence of a word length effect in this study may be explained by the constraints employed in generating the two sets of words. The words used were a subset of the words used in Baddeley et al. (1975), except the words we felt might be unfamiliar to the participants were replaced. Also, our study used not five-syllable words, but rather three-syllable words for long words because we believed it is difficult for Japanese learners of English to recall lists of five-syllable words. Further research is necessary to ascertain whether the modifications conducted in our study were appropriate or not.

As mentioned earlier, temporal word duration should be taken into consideration when the word length effect is discussed. This topic was not dealt with by Hulme et al. (2004) because the recall of pure lists of short words showed a large advantage against long words in their study and the words in each set were equal in the number of syllables. However, spoken duration was neither adjusted nor matched. In order to explore this question, duration time of each word spoken by the native speaker was measured, using SUGI Speech Analyzer software (<http://www.animo.co.jp/EN/product/>). Details of the words are given in Table 2.

Table 2. Spoken Duration in Seconds of Words Used in the Study

| Short words (one syllable) | | Long words (three syllables) | |
|---|---|---|---|
| Word | Duration | Word | Duration |
| Horse | 0.63 | Gorilla | 0.60 |
| Flu | 0.45 | Stomachache | 0.98 |
| School | 0.70 | Library | 0.77 |
| France | 0.62 | Mexico | 0.80 |
| Switch | 0.78 | Radio | 0.69 |
| Art | 0.54 | History | 0.68 |
| Book | 0.42 | Magazine | 0.78 |
| Gold | 0.50 | Calcium | 0.80 |
| Mean | 0.58 | Mean | 0.76 |

A one-way factorial ANOVA revealed that there was a significant difference between the mean duration times, $F(1, 14) = 9.42$, $p < .01$, $\eta_p^2 = .40$. Therefore, it can be said that the mean duration time of the three-syllable words used in this study is significantly longer than that of the one-syllable words. However, when it comes to individual words in each semantic category, the duration of a few of the one-syllable words exceeded that of some three-syllable words. For example, the duration of *horse* is longer than that of *gorilla*, and *switch* is longer than *radio*. If the one-syllable words *switch, school, horse,* and *France* are compared with three-syllable words without considering semantic categories, the duration of each word was longer than that of at least one of the three-syllable words.

Concerning the word length effect in terms of list-based accounts of rehearsal speed for foreign words, it seems that word duration may affect memory span. In measuring the word length effect, careful attention should be paid not only to the number of syllables in a word, but also to the spoken duration of a word.

Another explanation is based on the characteristics of the Japanese language. The Japanese language follows a quasiregular alternation of consonant and vowel. As a natural consequence, Japanese learners of English find it difficult to pronounce words containing complex strings of consonants or words ending with a consonant other than *n*. It might be the case with Japanese learners of English that the difference in the number of syllables does

not necessarily influence the time it takes to articulate a word. Japanese learners of English may not be able to differentiate between the time it takes to pronounce the one-syllable words such as *school, France, switch,* and *gold* and the three-syllable words such as *gorilla, radio, history, magazine,* and *calcium* used in the present study. That might be one of the reasons why the word length effect for list-based accounts was not observed in the study.

### *Research Question 3*

When comparing the recall of long and short foreign words in pure and alternating lists, to what extent do item-based accounts of the word length effect explain the result? In order to analyze the data in the same manner as Hulme et al. (2004), composite lists were derived from the two alternating conditions.

As Hulme et al. (2004) pointed out, direct comparisons can be made between how well a word of a given type (long or short) is recalled as a function of the list type it is embedded within (pure or alternating). The percentages of items recalled in the appropriate position expressed in this way are shown in Figure 4.

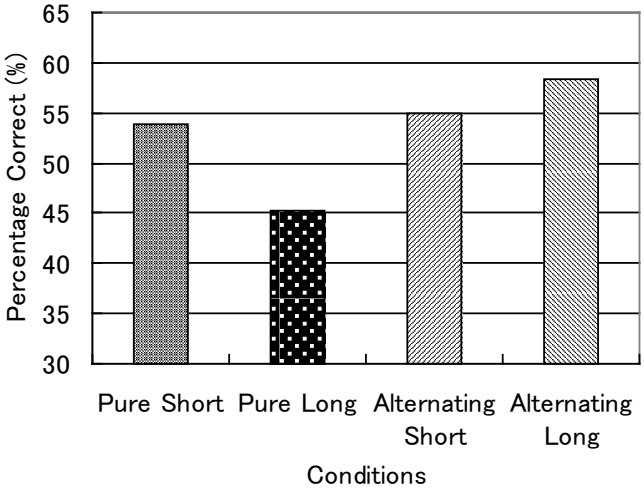


*Figure 4.* Mean percentage of short and long words correctly recalled in the appropriate position in pure and alternating lists.

The data in Figure 4 show that short words seemed to be recalled better than long words in pure lists but not in alternating lists. A 2 (short vs. long words) x 2 (pure vs. alternating lists) ANOVA on the percentage of words correctly recalled in the appropriate position showed a significant effect of list type, $F(1, 9) = 7.12$, $p < .05$, $\eta_p^2 = .08$, and a significant list type x length interaction, $F(1, 9) = 5.78$, $p < .05$, $\eta_p^2 = .05$. The effect sizes of these results were not large enough to be persuasive, so the results should be viewed with caution.

As found by Hulme et al. (2004), the interaction clearly reflected the fact that the substantial difference between the recall of long and short words in pure lists was *abolished*, as Hulme et al. put it, or negated in the alternating lists. The percentage of long words recalled correctly was marginally larger than that of short words.

Despite the fact that the participants in this study were recalling foreign words, the results were very similar to those of Hulme et al. (2004). Still, it seems difficult to assert that the word length effect is essentially a word complexity effect rather than a function simply of the number of syllables. On the other hand, the data seem to support the proposal that item distinctiveness plays a key role in retrieval.

Cowan (1999) focused on the function of the central executive in working memory. In his model, the central executive directs attention and controls voluntary processing. Attention and voluntary processing activate focus of attention and enhance maintenance and processing of information for a short time period. Attention is not paid to unchanged stimuli unless the person purposefully directs his or her attention to them. Unchanged stimuli cannot enter the focus of attention without voluntary processing. Conversely, a novel stimulus elicits attention and can enter the focus of attention directly. In support of his model, items in alternating lists in the present study seemed to elicit attention of the central executive because they were different from each other in word length. As a natural consequence, in pure lists, there was a tendency for long words to be more poorly remembered than short words, but in alternating lists, both the long and short words were recalled equally as well as the short words were in pure lists.

## Conclusion

The present study examined the credibility of the word length effect among 10 Japanese undergraduates, who listened to and attempted to recall 24 six-word sequences of foreign words. Specifically, we found the following: (a) serial position effects, such as the primacy effect and the recency effect, were

observed in the recall of foreign words, in line with the findings of Hulme et al. (2004) when participants recalled words in their L1; (b) when comparing the recall of pure lists of short words, pure lists of long words, alternating lists that begin with a short word, and alternating lists that begin with a long word, no significant difference was obtained in recall scores; and (c) when comparing the recall of long and short words in pure and alternating lists, there was a tendency in pure lists for long words to be more poorly remembered than short words, but in alternating lists, both the long and short words were recalled equally as well as the short words were in pure lists.

Research question 1 explored how Japanese learners recalled foreign words in immediate serial performance. Serial position effects similar to the results of L1 studies were found in this study. Foreign language learners may be able to recall speech input in the same way that native speakers do. The results for research question 2 do not necessarily negate or, as Hulme et al. (2004) put it, abolish the word length effect. Duration may have affected the results. If so, it supports research on list-based accounts of the word length effect. The results for research question 2 also indicate that more attention should be given to item distinctiveness, which elicits the attention of the central executive in working memory, as well as the word length effect with regard to subvocal rehearsal speed. The interpretation of the results for research question 3 overlaps with that of research question 2, confirming the crucial role of item distinctiveness in retrieval.

Baddeley (2007) noted, "The question of how serial order is stored and retrieved is still not fully understood" (p. 62). Further study should consider word duration, word familiarity, and item distinctiveness.

Because the word length effect did not seem to be disproved by this study, we can still assume effective use of the phonological loop capacity pedagogically is indispensable in listening comprehension. In order to make use of the loop capacity effectively, practice in repeating English input quickly and accurately should be a component of English instruction. For example, repetition practice with a focus on rehearsal speed and recognition accuracy should be assigned because it helps make effective use of the phonological loop and aides in backing up longer speech input. The practice should begin with short sentences then move gradually to longer ones. Shadowing practice is also considered to activate the phonological loop of working memory. For example, Tamai (2005) found that shadowing does not necessarily improve aspects of English language knowledge such as lexis or grammar, but it does work to reinforce the strategic aspects of listening such as prosodic features matching and rehearsal speed improvement. These practices

eventually promote listening comprehension. This adds more weight to the recommendation made in this paper that word duration, word familiarity, and item distinctiveness in speech should be taken into consideration in future studies of EFL listening comprehension.

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## Appendix

### *Instrument Used in Study*

1. magazine, school, stomachache, art, Mexico, book
2. history, stomachache, radio, Mexico, magazine, gorilla
3. book, gold, France, school, flu, switch
4. library, France, Mexico, school, magazine, flu
5. France, gorilla, book, magazine, horse, calcium
6. switch, horse, flu, art, book, gold
7. school, calcium, switch, Mexico, flu, history
8. radio, gold, library, switch, history, book
9. Mexico, library, gorilla, stomachache, magazine, calcium
10. book, library, school, magazine, art, gorilla
11. history, calcium, magazine, library, Mexico, radio
12. art, horse, flu, gold, school, book
13. history, calcium, gorilla, Mexico, stomachache, library
14. switch, library, gold, Mexico, flu, gorilla
15. library, book, calcium, flu, radio, switch
16. France, book, school, art, flu, switch
17. France, magazine, flu, Mexico, art, radio
18. France, art, book, switch, gold, horse
19. Mexico, gold, gorilla, switch, calcium, art
20. history, gorilla, magazine, calcium, library, radio
21. art, switch, flu, school, France, horse
22. book, radio, switch, calcium, France, library
23. history, library, gorilla, radio, magazine, stomachache
24. radio, France, calcium, art, gorilla, school