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Reading Span Test for Japanese Language Learners: Measuring Working Memory Capacity in L2 Reading

Fuyumi WATANABE

1. Introduction

Working memory is generally defined as a memory system that enables the temporary storage and processing of information to be used for future cognitive processes (Baddeley, 1992). Many researchers have suggested that working memory plays a crucial role in complex cognitive tasks such as reading. When reading text, a reader stores information from the preceding text in the working memory for a short period of time and uses it to understand the subsequent text. For example, when reading the following sentences; 'Taro and Hanako went to the park. They enjoyed the flowers there', the reader interprets that 'they', in the second sentence, refers to 'Taro and Hanako', and 'there' refers to 'the park' by utilizing the stored information from the first sentence. If the information from the preceding text were not stored, it would be impossible to understand the subsequent text correctly.

The most widely used measurement of working memory capacity is the reading span test (RST) which is designed to measure the efficiency of working memory during reading (Daneman & Carpenter, 1980). The test involves sentence comprehension and the additional storage of information; thus it requires both processing and storage, which are the functions of working memory. In the test, the participant is asked to read aloud several sentences presented on cards one by one, and verbally report the final word or the word underlined in each sentence. The idea behind this task is that reading the sentences aloud requires the processing and memorizing of the target word requires storage. These requirements are thought to ensure a closer approximation to cognitive tasks. It is assumed that good readers can read text

efficiently because they have more working memory capacity for storing the necessary information. A number of studies have examined the role of working memory using RST, and have shown that reading span scores have a significant correlation with reading comprehension scores (e.g., King & Just, 1991; Miyake, Just, & Carpenter, 1994).

Working memory is also controversial among L2 researchers. A number of L2 acquisition studies have investigated the role of working memory in L2 reading comprehension and suggested that working memory plays a role in foreign language acquisition (e.g., Harrington & Sawyer, 1992; Miyake & Friedman, 1998; Osaka & Osaka, 1992). Miyake and Friedman (1998) found that working memory measured by RST had a relationship with L2 syntactic comprehension ability. Moreover Harrington and Sawyer (1992) found a strong relationship between L2 proficiency and working memory performance in the L2 reading span test. Although the relationship between working memory capacity and reading performance has been explored, little research has discussed the process of conducting the test. L2 reading is different from L1 reading in several ways. In L2 reading, readers often encounter unknown words and stop reading to consult a dictionary. Moreover, when reading text written using kanji, readers often encounter kanji that they do not know, and stop reading. If such cases occurred in the reading aloud session of RST, it would be difficult to measure their reading span appropriately. In this study, procedure for selecting the materials and conducting the L2 version of the RST were discussed. Moreover, the reading process of Japanese learners was investigated based on the results of the RST.

2. Method

Participants

Forty-four undergraduate students at a Chinese university participated in the present study. They were all third year students majoring in Japanese, and their native language was Chinese. None of the participants had studied in Japan.

Materials

For the RST, 70 sentences were selected from Japanese text books used in elementary school. In order to control the sentence length, long sentences were rewritten. If words or kanji which participants did not know were

Table 1. Examples of sentences used in the RST

小学校の前の道には <u>きれいな</u> 桜が咲いていた。
‘On the street in front of an elementary school, the beautiful cherry tree was in bloom.’
彼が私のために、忙しい中準備してくれたことがうれしかった。
‘I was glad that he put aside the time to make arrangements for me during his busy schedule.’

Note. The underline of the target word was drawn in red.

included in these sentences, they would not be able to continue reading aloud. As a result, it would be difficult to measure their reading span correctly. To avoid this problem, prior to the test, unknown words and kanji were investigated by five students who were at the same Japanese level as the participants of the present study and who would not participate in the RST session. They received sheets on which all the sentences used in the RST were printed, and marked any words and kanji that they did not know. After that, the unknown words were replaced with easier words, and furigana (glosses indicating reading pronunciation) was added above the kanji they marked. The average number of letters for each sentence was 29.3 ($SD=3.93$) and the average number of letters for each target word was 4.2 ($SD=1.11$). In addition, the word class of the target words was controlled; eighteen nouns, eighteen verbs, seventeen adjectives, and seventeen adverbs. Each sentence was printed on a white card, and the cards were arranged in five sets, each of which comprised two, three, four, and five sentences. Within the sets, the sentences and target words were semantically not related to each other.

Procedure

The participants were tested individually. After receiving general instructions, more detailed instructions were given. The instructions emphasized the importance of reading the sentences as fast as possible. Before the test, the participants were given practice to ensure that they were able to perform the task.

In the test session, the participants were asked to read sets of sentences aloud, and simultaneously attempted to recall the word that was underlined at

the end of each trial. The sentences were presented on cards, with one sentence at the center of each card. As soon as the participant finished reading a sentence, the next sentence was presented and participant was told to continue reading aloud. At the end of each trial, a blank card appeared and the participant was asked to recall the target word of each sentence in that trial. The order of reporting the target words was based on the free recall procedure, but in order to avoid the recency effect, it was prohibited to report the target word in the last sentence first. The test involved four levels, starting from two to five sentences, with each level containing five trials. The number of sentences in a trial was incremented from trial to trial, and the participant's reading span was defined as the maximum number of sentences she/he could read while maintaining recall of the target words correctly. Half credit was given if the participant was correct in two out of the five trials at a particular level. For example, if a participant were to successfully recall in three out of five trials in the three-sentence condition, the calculated reading span was 3. If the participant correctly recalled in only two of five trials, the calculated reading span would be 2.5. Though the test is usually terminated when the participant fails to recall in three trials at a particular condition, in this study, the test was continued until the participant failed to recall in all trials. This was done in order to explore the procedure of the test and the L2 reading process.

3. Results and discussion

Procedure

As stated in the introduction, the RST is assumed to require participants not only to read aloud but also to understand the sentences in order to tax their processing capabilities. In the test of the present study, evidence implying that they actually did it was observed. Many participants sometimes read slowly at points where the syntactic structure was confusing or where they encountered an unfamiliar word. No case was observed where a participant stopped reading in mid-sentence because of the unknown words or unknown kanji. This indicated that the preliminary study helped them to carry out the reading aloud task smoothly. Replacing the unknown word with an easier word and adding furigana to unknown kanji in advance appeared to be necessary when we conducted the Japanese version of the RST with learners. However, a few

participants read some Katakana words such as ‘カメラマン’ (cameraman) twice. These words seemed to be unfamiliar to them. Previous studies have mentioned that Japanese learners have difficulty in reading Katakana words. If sentences contain Katakana words, especially if used as target words, it would be better to confirm whether they can read them aloud smoothly.

After finishing the test, many participants verbally reported that it was more difficult than they had expected. In their Japanese language class, they were often required to memorize long sentences, and sometimes remember long paragraphs for practice, so they were used to memorizing Japanese. This fact demonstrated that the RST does not simply measure the participant’s skill in memorizing information.

Little research has studied the way of selecting materials used in the RST for L2 learners. The present study showed the importance of the preliminary study. It suggested that the effect of familiarity should be considered when selecting materials. Additionally it seems to be better not to use Katakana words that are unfamiliar to the participants.

Reading span scores

Reading span scores were calculated based on the number of sentences participants could read while recalling the target words successfully. The reading span of the 44 participants varied from 1.5 to 3 and the average rate was 1.83 ($SD=0.49$). Most participants could not recall the target words successfully in the three-sentence condition and no one successfully recalled them in the four-sentence condition. The participant with the highest reading span was a student who often took part in Japanese speech contests and had won first prize several times.

Table 2 shows the average recall rate in the two-sentence condition. The average recall rate of each target word was 67.3%, and 25 out of the 44 participants successfully recalled it in more than three out of five trials. In this condition, ten target words were presented and the highest and the second highest recall rate were over 90%. As shown in Table 2, the word with the highest recall rate was presented in the first trial and the word with the second highest rate was included in the first sentence of the third trial. One possible reason for this result is the difference in the difficulty of recalling. The participants had to read five sentences and retain five words before conducting

Table 2. Average recall rate in two sentence condition (%)

Trial	1		2		3		4		5	
Sentence	1	2	1	2	1	2	1	2	1	2
Recall rate	91	57	80	68	93	82	61	57	43	41

Table 3. Average recall rate in three sentence condition (%)

Trial	1			2			3			4			5		
Sentence	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
Recall rate	39	27	50	43	16	23	41	39	57	59	48	34	23	11	25

the second half of the test. Therefore, it appeared to be easy to become confused in the second half. In fact, the words with lower recall rate, lower than 50%, were both included in the last trial. Furthermore, in the second half of this condition, some participants often recalled wrong words which had been presented in other trials conducted before. These results imply that the more they read, the easier it was to become confused in L2 reading.

In the three-sentence condition, on the other hand, the average recall rate was only 35.7% and only one participant successfully recalled the words in three trials. This indicates that most of them forgot the target words while reading three sentences aloud. As shown in Table 3, the recall rates in the three-sentence condition were much lower than those of the two-sentence condition. The highest recall rate was under 60% and the lowest was 11%. Unlike the two-sentence condition, no influence of the trial order was observed. The word with the highest recall rate did not appear in the first half of the trials and the word with the lowest rate was not presented in the second half. This indicates that retaining three words while reading three sentences was very difficult for learners. Osaka and Osaka (1994) administered the Japanese version of the RST to Japanese university students and reported that their reading span was 3.45 on average. Their test was developed for Japanese native speakers, so the sentences used in their test were more difficult than the sentences used in the present study. Taking this fact into account, it could be argued that the average reading span of the participants in this study was relatively low. These results demonstrate how difficult it is for learners to read Japanese text as native speakers do. If the information could not be stored for

a period of time, it was impossible to integrate the subsequent text; as a result, the reader could not properly comprehend the situation represented by the text.

In the field of Japanese education, most studies on the reading comprehension process of learners have mainly focused on the effect of text structure or text type. Further study is needed to clarify the L2 reading process, taking into account the effect of working memory capacity.

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