Effects of Working Memory Capacity of EFL Learners on Text Comprehension and Perceptual Cognitive Loads: Using Three Reading Modes

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Abstract

The present study investigates whether the working memory capacity of English as a foreign language (EFL) learners affects text comprehension and cognitive load among three reading modes (silent reading, listening-while-reading, and oral reading). Since the three reading modes require different input and output processing, one may assume that readers perceived different cognitive loads in each reading mode. In this study, 63 Japanese EFL learners took a reading span test to measure their working memory capacity, and read in one of the three reading modes, performing a written recall task as a measurement of comprehension. A questionnaire measured the learners’ perceptual cognitive load during reading. The findings revealed that individual working memory capacity affected EFL reading comprehension regardless of reading modes, which reconfirms the importance of working memory capacity on EFL reading comprehension. However, the findings suggest that working memory capacity did not affect perceptual cognitive load: Learners with large working memory capacity perceived almost the same cognitive load as those with small capacity, but they were better at adequately allotting their cognitive resources. Finally, cognitive load results are related to text comprehension. This paper concludes with suggestions regarding adequate situations of introducing different reading modes.

1. Introduction

In classes of English as a foreign language (EFL) programs, students frequently read texts aloud (i.e., oral reading) or read texts while listening to recordings that contain the same content as the written text (i.e., listening-while-reading) in order to promote reading and other skills (Allen, 1985; Diao & Sweller, 2007; Holmes, 1985; McCallum, Sharp, Bell, & George, 2004; Salasoo, 1986; Ushiro, 1995). These different reading styles are called reading modes (Allen, 1985; Holmes, 1985; Salasoo, 1986). Students can improve their reading skills, including accuracy and efficiency, through the different reading modes. On the other hand, learners might have some difficulty in comprehending texts during oral reading and listening-while-reading because they
have to process a considerable amount of information at the same time. The current study attempts to figure out what kind of learner obtains the greatest benefit from each reading mode, focusing on their cognitive resource (i.e., working memory capacity). Therefore, three reading modes that might have different demands of working memory were targeted: silent reading, listening-while-reading, and oral reading. The process of each reading mode is different, and the next section reviews them.

1.1 Relationships Between Working Memory and Reading Modes

When learners read and comprehend a text, working memory plays a critical role (Baddeley, 1986; Daneman & Carpenter, 1980). The two main functions of working memory are the simultaneous storage and processing of information (Baddeley, 1986; Daneman & Carpenter, 1980; Osaka, 1998). In particular, working memory becomes more important when learners are required to undertake complex cognitive tasks, such as language comprehension. When task requirements exceed resource capacity, a trade-off relationship exists between processing and storage functions, as cognitive resources available in working memory, also known as working memory capacity, are limited. The shortage of capacity negatively affects task performance, through factors such as slower processing and information loss. For example, when learners read difficult texts, they engage their working memory capacity to ascertain the meaning of the passage and, as a result, fewer available resources remain for storage. Since working memory capacity differs between individuals and these differences relate to task success, measuring capacity is important to optimize readers’ skills (Friedman & Miyake, 2005; Osaka, 1998).

With respect to reading, a phonological loop is a subsystem of the working memory model (Baddeley, 1986) that processes information related to language. A phonological loop has two important roles: (a) decoding written words in phonological form for storage and rehearsal, and (b) storing phonological information for a few seconds and refreshing the stored sounds with sub-vocalization (inner speech). The three reading modes targeted in this study closely relate to the phonological loop. In the phonological loop, input information such as letters must be converted to phonological form, which is known as phonological decoding. Even if readers do not speak aloud, silent reading requires them to process phonological information using inner speech in their minds (Baddeley, 1986; Takahashi, 2007, 2013). In listening-while-reading, readers silently read texts, and listen to speech that corresponds to a written script. The recording works as a model of inner speech, and helps readers construct phonological presentation. This is why listening-while-reading is utilized as an assistance to reading (Amer, 1997; Winn, Skinner, Oliver, Hale, & Ziegler, 2006). Finally, oral reading represents the process of phonological rehearsal as a form of speech in the phonological loop (Kadota, 2007).

Regarding the role of working memory for different reading modes, Takahashi (2007) insisted that the role of working memory was different in silent and oral reading in Japanese native (L1) reading. She investigated sentence comprehension in silent and oral reading. Her finding
indicated that silent-reading comprehension depended on learners’ working memory capacity; while comprehension in oral reading was unaffected, even if learners had limited working memory capacity. This might be a benefit of phonological convention in oral reading.

As such, the working memory of readers relates to the process and comprehension of the three reading modes. Many studies have discussed the high correlation between learners’ working memory capacity and their reading proficiency or comprehension in L1 and EFL reading (Daneman & Carpenter, 1980; Friedman & Miyake, 2005). In particular, considering that English as a second language (L2) and EFL learners’ working memory capacity is more limited than L1 readers, working memory capacity affects comprehension to a greater extent compared with L1 reading (Berquist, 1997). Therefore, it is natural to suppose that the working memory capacity of EFL learners affects reading comprehension in different reading modes.

1.2 Comprehension Among Reading Modes

Although previous research on reading modes’ comprehension has generated controversy, most studies agree that silent reading is the most comprehensible mode of the three (Allen, 1985; Diao & Sweller, 2007; McCallum et al., 2004; Salasoo, 1986). Some experimental studies have used silent-reading tasks as the control condition. The following are the major studies of reading-mode comprehension.

**Oral reading.** When compared to silent reading, most studies reveal that oral reading sometimes impedes, or does not promote readers’ text comprehension (Allen, 1985; Holmes, 1985; McCallum et al., 2004; Salasoo, 1986). They suggest that the reason is due to readers’ lack of sufficient working memory capacity. Salasoo (1986) shows that oral reading positively affects integration of higher-level processing, such as inferences, but does not improve comprehension itself because of untenable double encoding (i.e., visual and auditory inputs) into readers’ working memory. Several studies on EFL reading show that students sometimes read aloud fluently without sufficient comprehension: “eye-mouth-reading” or “parrot reading” (Miyasako, 2002; Ushiro, 1995). These phenomena might occur due to high load on readers’ working memory.

Despite such disadvantages of oral reading, a few studies have suggested that oral reading promotes the reading comprehension of learners with low proficiency levels or limited working memory capacity (Miller & Smith, 1985; Takahashi, 2007). Miller and Smith (1985) discussed that oral reading has an advantage for L1 children because it compelled each word to be allotted. Similarly, Takahashi (2013) reviewed three advantages of oral reading for the comprehension of Japanese L1 children. First, readers are more familiar with phonological information in oral reading because they have used spoken language before learning to read. Second, the production of pronunciation in oral reading is an active process requiring large cognitive resources, but at the same time, learners can retain textual information as well. Finally, readers with limited working memory capacity are compelled to use such lower-level processing as phonological processing or
to pay attention in oral reading, while the same readers cannot process effectively in silent reading because of lack of working memory capacity. The first advantage does not always apply to EFL reading, but the other two are surely advantages of oral reading for EFL students.

**Listening-while-reading.** The listening-while-reading mode is not as common as silent and oral reading. Amer (1997) promoted the positive effect of listening-while-reading for L2 elementary school students. Amer concluded that teachers' reading to students (listening-while-reading) prevents too much bottom-up processing, such as focusing on meaning of a particular word or phrase, and therefore listening-while-reading task promotes reading comprehension for L2 children. On the other hand, some researchers assume that listening-while-reading comprehension is inferior to silent reading, due to loads of processing (e.g., Diao & Sweller, 2007). The following section introduces such loads of processing.

1.3 Cognitive Load Among Reading Modes

The amount of mental effort required by a task is referred to as the cognitive load (Kadota, 2007; Raney, 1993). According to the cognitive load theory proposed by Swellers (e.g., Chandler & Sweller, 1991; Diao & Sweller, 2007; Tindall-Ford, Chandler & Sweller, 1997), the cognitive load limits learners’ available cognitive resources. Thus, when learners perform difficult tasks, their cognitive load becomes heavier which lessens comprehension. In other words, cognitive load contributes to task difficulty. This theory also puts emphasis on the cognitive load of tasks during teaching. The following effect was introduced in order to impose on learners an adequate load during learning.

The cognitive load theory includes some subordinate effects. One of these is the redundancy effect (Diao & Sweller, 2007), which occurs when learners gain the same information from two or more sources (e.g., from written and spoken passages, or from a passage and a diagram). Processing redundant information requires additional cognitive resources, which does not lead to readers developing deep comprehension. In other words, when the cognitive load is high, the integration of different types of information might have negative effects on comprehension (Chandler & Sweller, 1991). For example, during listening-while-reading, a reader's comprehension became worse compared to when only one format (only texts or only recordings) was presented (Diao & Sweller, 2007; Torcasio & Sweller, 2010). While these studies did not mention cognitive loads during oral reading, studies on oral-reading comprehension implied that oral reading is the only one of the three reading modes that contain output processing, and thus the production process becomes overloaded and disturbs comprehension as readers have to focus on output (Holmes, 1985; Miyasako, 2002; Salasoo, 1986). In addition, task familiarity is another factor that affects cognitive load. Tanaka (2013) identified the characteristics of the three reading modes using questionnaires, and argued that Japanese EFL learners have to process inputs and output during oral reading. However, learners are familiar with the reading-aloud task, which is an
advantage of oral reading comprehension over listening-while-reading. Based on these studies, it is possible to predict that cognitive load on silent reading is lower than oral reading and listening-while-reading.

In summary, most studies that compare reading modes indicate that readers’ working memory capacity is related to comprehension or cognitive load. However, there is a controversy as to role of reading modes. Research on the cognitive load theory suggests that difficulty in comprehension depends on the total amount of inputs and outputs, and exceeding information may impede comprehension (Chandler & Sweller, 1991; Diao & Sweller, 2007). On the other hand, some studies have implied that listening-while-reading and oral reading have advantages in controlling readers’ top-down and bottom-up processes for beginner readers or learners (Amer, 1997; Miller & Smith, 1985; Salasoo, 1986).

1.4 Focus of This Study

As seen so far, many studies have examined the relationship between reading comprehension and readers’ working memory capacity as well as comparing reading comprehension among reading modes. While few have combined reading modes with readers’ working memory capacities or cognitive loads (e.g., Diao & Sweller, 2007), the problem is determining which reading mode could best minimize the damage to cognitive load and promote comprehension among learners. However, they have not focused on the relationships between EFL learners’ working memory capacity, reading comprehension, and perceptual cognitive load among different reading modes. Accordingly, the present study examines the effects of EFL learners’ working memory capacity on reading comprehension and perceptual cognitive load among the three reading modes.

Based on previous studies, the relationship between EFL learners’ working memory capacity and reading comprehension and perceptual cognitive load among the reading modes are assumed as follows: Learners with large working-memory capacity comprehend texts better than those with limited capacity, even when the reading mode requires extra cognitive resources. The first research question (RQ1) focuses on EFL learners’ working memory capacity and their comprehension. Although previous studies have generated some controversy regarding reading comprehension of the three reading modes for L1 readers and EFL learners, this study attempts to figure out the interaction between reading modes and learners’ working memory capacity, rather than to decide which reading mode is the best for comprehension. RQ2 investigates the relationship between learners’ working memory capacity and perceptual cognitive loads among the three reading modes. The cognitive load theory and other studies on reading modes assume that the reading modes cause different cognitive loads. On the other hand, they did not examine the effects of working memory capacity on cognitive loads in L1 nor EFL reading. The general assumption above indicates that EFL learners with large working memory capacity comprehend texts well with demanding reading modes. Possible reasons are (a) because they perceive less
cognitive loads than learners with limited capacity and (b) because they could endure those loads, although they perceived the same loads as learners with limited capacity. The two research questions (RQs) are as follows:

RQ1: Does working memory capacity of EFL learners affect comprehension on each mode?  
RQ2: Does working memory capacity of EFL learners affect cognitive loads on each mode?

2. Method

2.1 Participants  
A total of 66 Japanese undergraduate and graduate students participated in this study. The data of three students who had been to English-speaking countries for more than 10 months was excluded; therefore the final number of dataset was 63. Participants read the passage in one of the three modes: silent reading, listening-while-reading, or oral reading. Thus, there were approximately 20 participants per reading-mode group.

2.2 Materials  
Four kinds of materials were prepared for the study: (a) reading passage, (b) questionnaires on perceptual cognitive load, (c) reading span test, and (d) reading proficiency test.

Reading passage. In order to choose proper passages, to ascertain unknown words for learners, and to decide the reading rate of recordings during listening-while-reading, a pilot study was conducted with two undergraduates who did not participate in the experimental study. Based on the results, the short passage, “Money helps the teacher” was derived from the website Adult Learning Activities (California Distance Learning Project, 2005). This website contained an English passage with native utterances. The total number of words in the passage was 199 and the readability of the text was 5.2 on the Flesch-Kincaid Grade Level readability scale (for the whole passage, see Appendix A). The recording for the listening-while-reading mode was originally 165 words per minute (wpm) originally, but slowed to 106 wpm based on the pilot study.

Questionnaires on perceptual cognitive load. To examine the perceptual cognitive load by participants while they read the passage, questionnaires on the cognitive load of each reading mode were prepared (see Appendix B). The questions were 7-point Likert scale based on the research of Diao and Sweller (2007) and Ushiro (1995). Only four items that were compatible with the three reading modes were utilized for analysis.

Reading span test (RST). Osaka’s (1998) RST for learners of English as a second language was utilized to assess the working memory capacity of each participant, which enabled the
participants to be divided into two groups: Upper and Lower. The reading sentences included five sets of two to five sentences, with 70 sentences in sum.

**Reading proficiency test.** To confirm the level of proficiency of the learners in each group, Eiken’s test was adapted for a reading proficiency test. The reading proficiency test includes six reading passages from Pre-1, 2 and Pre-2 grades.

### 2.3 Procedure
Firstly, the general purpose of this study was disclosed to all participants before the main test. The main test session included the RST, reading session, and reading proficiency test. The participants took the RST on a computer screen with almost the same procedure as Osaka (1998). The procedure for the RST was as follows: The participants read sets of two to five sentences aloud and then attempted to remember the last word of each sentence. They had to recall the sentence-final words in English without referring back to the texts. Each set had five trials. Before the RST began, the participants practiced two trials of two-sentence level. The experimenter placed the computer screen in front of the participants. As soon as the participants finished reading the sentence, the experimenter operated the computer to turn to the next page in order to prevent participants from articulating a rehearsal. On the answer sheet, they wrote down all the final words of the sentences in each set.

After the RST, participants read the passage in a given reading mode. To consider the learners’ burdens during reading tasks, the reading mode condition is designed as a between-participants factor, rather than a within-participants factor. In the oral and silent reading groups, the participants read one sentence at a time to prevent them from rereading. Meanwhile, participants in the listening-while-reading group silently read the text on paper, while listening to the spoken version that was identical to the writing. They were asked to read the text silently at the same speed as the recorded utterance. The participants in each reading mode were instructed to try to comprehend the text beforehand, and there was no direction about fluency or accent in the oral-reading group. When the participants finished reading, 10 minutes were given to write down what they remembered about the passage in Japanese (learners’ L1) on the answer sheet. Later, they answered the questionnaire on the cognitive loads as they perceived. Finally, within 30 minutes the participants performed the reading proficiency test. The whole session lasted for 90 minutes.

### 2.4 Scoring
**Written recall protocols and questionnaire.** As with the index of reading comprehension, written recall protocols were scored. Prior to scoring, two raters divided the text into idea units (IUs) based on Ikeno (1996). Disagreements in the IU segments were resolved by discussion (the
inter-rater agreement = 95.96%). According to this IU segmentation, two raters assessed the
passage separately. They counted the number of IUs that were correctly produced in participants' 
protocols (the inter-rater agreement = 87.83%). Any discrepancy was resolved through discussion, 
and one of the raters scored the remaining data. For the index of cognitive loads, the points of four 
items on the questionnaire were averaged.

**RST.** The scoring of the RST was based on the total number of words (Friedman & Miyake, 
2005) to provide a more adequate assessment of working memory capacity. The total number of 
sentence-final words recalled across all trials was counted. The maximum score was 70 points in 
this study. This continuous measure provides more evidence for the validity of the RST and the 
distinction between participants with various capacity (i.e., span level in Daneman & Carpenter, 
1980).

2.5 Data Analyses

There were two main areas of analyses in this study: To examine RQ1, a two-way analysis 
of variance (ANOVA) was conducted on recall scores with two between-participant variables: 
Reading modes (Silent reading, Oral reading, and Listening-while-reading) and RST (Upper and 
Lower groups). Another two-way ANOVA with the same design as the previous one was 
conducted on questionnaire answers on cognitive loads in order to investigate RQ2. All analyses 
in this study utilized an alpha level of .05.

3. Results and Discussion

3.1 Homogeneity Among the Three Reading Groups

Preliminary analysis was conducted before the main analyses to confirm the homogeneity of 
working memory capacity among the three reading mode groups: A 2 (RST: Upper and Lower) 
× 3 (Reading modes: Silent reading, Listening-while-reading, Oral reading) two-way ANOVA on 
the RST scores. The results indicated that there was a significant main effect of RST, \( F(1, 57) = 
87.98, p < .001, \eta^2 = .64; \) and there was no significant main effect for the groups of reading modes. 
The participants in the Upper RST group possessed significantly larger working memory capacity 
than those in the Lower group and there were no differences between the three reading-mode 
groups. Thus, the level of homogeneity of working memory capacity among the three reading 
mode groups was sufficient. Table 1 presents the descriptive statistics of the RST score. 
Participants with a RST score greater than 40 composed the Upper group, which corresponds with 
Level 3 and 4 in Daneman and Carpenter’s (1980) scoring.

In order to ensure the homogeneity among the three reading groups, preliminary analysis of 
the reading proficiency test was also carried out. As this study does not focus on the learners’ 
proficiency levels, the analysis includes only reading mode groups as one independent factor. A
one-way ANOVA on the reading proficiency test confirmed again the homogeneity among the groups, $F(2, 62) = 0.30, p = .744, \eta^2 = .01$. ($M = 22.45, SD = 0.99$ for the silent reading group; $M = 21.35, SD = 1.03$ for the oral reading group; $M = 21.86, SD = 1.01$ for the listening-while-reading group). Based on these results, the following analyses were carried out.

Table 1

<table>
<thead>
<tr>
<th>RST</th>
<th>Silent Reading</th>
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<th>Listening-while-reading</th>
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<th>Oral Reading</th>
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<td></td>
<td>$n$</td>
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<td>$M$</td>
<td>$SD$</td>
</tr>
<tr>
<td>Upper</td>
<td>12</td>
<td>44.83</td>
<td>3.83</td>
<td>11</td>
<td>43.45</td>
<td>3.14</td>
</tr>
<tr>
<td>Lower</td>
<td>10</td>
<td>33.40</td>
<td>4.76</td>
<td>10</td>
<td>33.90</td>
<td>4.31</td>
</tr>
<tr>
<td>Total</td>
<td>22</td>
<td>39.77</td>
<td>7.04</td>
<td>21</td>
<td>38.90</td>
<td>6.10</td>
</tr>
</tbody>
</table>

Note: Possible maximum score = 70.

3.2 Effects of Working Memory Capacity on Comprehension of Each Mode (RQ1)

The 2 (RST: Upper and Lower) $\times$ 3 (Reading modes: Silent reading, Listening-while-reading, and Oral reading) two-way ANOVA on recall performance was carried out to obtain answers for RQ1. Table 2 shows the descriptive statistics of the proportion of recall performance in each reading mode. This analysis discovered an insignificant interaction between RST and Reading modes, $F(2, 57) = 0.30, p = .739, \eta^2 = .01$. The results of the main effects of RST showed that the upper group recalled the passage significantly better than the lower group, $F(1, 57) = 4.93, p = .030, \eta^2 = .08$. The main effect of the reading mode group was also significant, $F(2, 57) = 3.32, p = .043, \eta^2 = .10$. A multiple comparison suggested that the silent reading group comprehended better than the listening-while-reading group ($p = .043$), but there were no significant differences between the silent reading and oral reading groups ($p = .312$), nor between the oral reading and listening-while-reading groups ($p > 1.00$).

Table 2

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<tr>
<th>RST</th>
<th>Silent reading</th>
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<th>Listening-while-reading</th>
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<th>Oral reading</th>
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<td>$n$</td>
<td>$M$</td>
<td>$SD$</td>
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<td>21</td>
<td>25.24</td>
<td>13.76</td>
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</tbody>
</table>

This section first compares reading comprehension for the three modes, and then discusses the effects of learners’ working memory capacity. As for comprehension, the results revealed that
the comprehension of silent reading was significantly superior to listening-while-reading as shown in Figure 1. The finding of the lowest comprehension in listening-while-reading supports previous studies that compared comprehension in listening-while-reading and silent reading, both in L1 and L2 (Diao & Sweller, 2007). The insignificant difference between silent- and oral-reading comprehension is also consistent with previous studies (Allen, 1985; Holmes, 1985; McCallum et al., 2004; Salasoo, 1986). In contrast to EFL studies (Miyasako, 2002; Ushiro, 1995), the “eye-mouth reading” effect did not occur in oral-reading comprehension. The participants in this study were instructed to read for comprehension. Thus, they could allot their cognitive resources to comprehension, rather than their output processing (i.e., utterances). The effect of such direction before reading aloud was confirmed in Ushiro (1995). In addition, positive effects of oral reading on text retention (Takahashi, 2013) must prevent a deterioration in comprehension, while utterances in oral reading require large cognitive resources.

The results of the main effect of RST in the two-way ANOVA supported the view that learners’ working memory capacity affects reading comprehension in each reading mode. This is quite understandable as many studies have emphasized the importance of readers’ working memory capacity during reading (e.g., Daneman & Carpenter, 1980; Takahashi, 2007). Furthermore, Takahashi (2007) focused on the different role of working memory between reading modes. She found that silent reading comprehension depends on working memory, but that L1 readers maintained their comprehension in oral reading, even when their working memory capacity was limited. In addition, some studies for L1 children found out that oral reading had advantages for readers with limited capacity (Miller & Smith, 1985; Salasoo, 1986). This study also expected that the three reading modes have different roles in working memory. The non-significant interaction in this study did not support their findings, and it meant that working memory helps learners comprehend text in all three reading modes. A possible reason for this contradiction is the difference in length of the material used. Takahashi measured reading comprehension using a sentence, while in the present study we used a relatively long passage comprising 15 sentences. Several studies have indicated that reading a passage differs from reading a single sentence. More importantly, the target language may be another reason for the different results. Takahashi’s study focused on working memory capacity while reading the native language, whereas this study looked at the working memory capacity of EFL learners, which is more limited than L1 learners. The different results in L1 and EFL studies correspond with Berquist’s (1997) assertion that the importance of working memory capacity increases for EFL reading because EFL learners’ working memory capacity is more restricted than that of L1 readers. Thus, the contribution of working memory capacity did not differ among reading modes in EFL reading. Therefore, comprehension would be impeded by their restricted capacity, regardless of the reading mode. Accordingly, though the importance of working memory capacity does not differ among reading modes, EFL learners’ working memory capacity affects comprehension in the three different reading modes.
3.3 Effects of Working Memory Capacity on Cognitive Load of Each Mode (RQ2)

To examine RQ2, another two-way ANOVA on questionnaire answers was carried out. Table 3 shows means and standard deviation of cognitive load. The results indicate that there was no significant interaction, $F(2, 57) = 5.21, p = .153, \eta^2 = .06$; nor main effect of RST, $F(1, 57) = 0.00, p = .966, \eta^2 = .00$. However, the significant main effect of reading modes was determined, $F(2, 57) = 5.21, p = .008, \eta^2 = .16$. According to subsequent analysis, the participants in the listening-while-reading group perceived higher cognitive load than in the silent reading group ($p = .007$). The significant differences between oral and silent reading groups, and between oral and listening-while-reading groups were not found out.

Table 3

<table>
<thead>
<tr>
<th>RST</th>
<th>Silent reading</th>
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<th>Listeners-while-reading</th>
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<th>Oral reading</th>
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<td>n</td>
<td>M</td>
<td>SD</td>
<td>n</td>
<td>M</td>
<td>SD</td>
<td>n</td>
</tr>
<tr>
<td>Upper</td>
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<td>0.96</td>
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<td>1.09</td>
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<td>4.70</td>
<td>1.20</td>
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</table>

Note. Maximum possible score = 7 for cognitive load; larger scores show higher loads.

The second research question discusses the effect of working memory capacity on cognitive loads. Prior to the main discussion, the differences of cognitive load among reading modes were confirmed. The outcomes of the two-way ANOVA on questionnaire answers indicated that the cognitive load of listening-while-reading was the largest, while silent reading and oral reading were smaller. The finding that the listening-while-reading possesses higher loads than silent reading is consistent with the redundancy effect of the cognitive load theory (Diao & Sweller, 2007). In particular, learners might have difficulties in comprehension according to reading rates of the recording (more than 100 wpm in this study) in listening-while-reading. Note that Diao &
Sweller utilized quite slow recordings that were less than 80 wpm. In addition, listening-while-reading is not so popular compared to silent and oral reading tasks, which leads to an increase in learners’ cognitive loads for listening-while-reading. As for oral reading, previous research implicated the overloads during oral reading (Holmes, 1985), but the finding of this study did not support it. The possible reasons are that learners in the oral-reading group read the passage in each sentence, but they had an opportunity to slow down their reading rates strategically; and also that task familiarities of oral reading have positive effects in reducing cognitive loads (Tanaka, 2013).

The finding shows that EFL learners’ working memory capacity did not affect their cognitive load during three reading modes. This result supports one of the possible reason, as shown in Section 1.4, that learners with large working memory capacity perceived the almost same cognitive loads as one with low capacity, but they could process large loads in their working memory and allot their resources effectively to comprehension at the same time. Another possible reason is also likely to happen, which shows that learners with large capacities perceive light cognitive loads during reading. However, it should be noted that tendencies of cognitive loads on oral reading mode are slightly different from the other two modes. While a statistically significant difference was not detected, Figure 2 shows that learners with small working memory capacity perceived slightly lighter cognitive loads than ones with a large capacity. The outcome shows that learners with large capacity do not always perceive lighter cognitive loads. The reason why scores of cognitive loads on oral reading show a different tendency from the other modes might be a function of oral reading as an adjusting allotment for cognitive resource (Takahashi, 2013), although discussion of RQ1 failed to find out the differences of working-memory’s roles.

Finally, considering RQs 1 and 2 together, results of comprehension and cognitive load were consistent: The most demanding listening-while-reading mode allowed learners the most limited comprehension, which fully agreed with the cognitive load theory.

4. Conclusion

In the current study, the effects of working memory capacity on EFL learners’ comprehension and cognitive loads among three reading modes (i.e., silent reading, listening-while-reading, and oral reading) were demonstrated. A few studies have investigated relationships between reading comprehension and working memory on various reading modes (e.g., Daneman & Carpenter, 1980; Diao & Sweller, 2007; Salasoo, 1986; Takahashi, 2007). The findings of this study lead to the following three conclusions. First, reading comprehension depends on learners’ working memory capacity regardless of reading modes, and this is a specific phenomenon of EFL learning (Berquist, 1997). Second, EFL learners’ working memory capacity does not affect cognitive load for the three types of reading, indicating that learners with large working memory capacity process large cognitive loads, rather than they perceive lighter loads. Finally, findings of comprehension were consistent to the cognitive loads: Learners perceived the
highest cognitive loads and they comprehend the least on listening-while-reading. Despite the large loads of output processing on oral reading, their comprehension and cognitive load were both maintained because of task familiarity and roles of allocation of cognitive resource.

This study failed to find out the interaction between learners' working memory capacity and comprehension or cognitive loads among three reading modes. However, other findings suggested some implications regarding the appropriate situation for introducing each reading mode. Performance in each reading mode is related to cognitive load as perceived by the learners. Consistent with these results, routinely introducing oral reading is one effective way to enhance reading skills, because it helps learners with limited working memory allot their cognitive resources. Because of high cognitive load, listening-while-reading should also be repeatedly performed rather than have a single use in order to comprehend texts fully. Another finding indicates that reading with the corresponding sound is difficult for many learners, thus, speech rate needs be taken into consideration. If manipulation of speed is difficult, teachers should confirm meanings of text before or after introducing listening-while-reading.

The present study had three limitations: (a) the method for rating cognitive load, (b) the experimental materials, and (c) the experimental design. Using questionnaires is a general method to measure cognitive loads in previous studies, but questionnaires do not always allow reflection of the actual cognitive load of a given task. To measure cognitive load itself, Raney (1993) used a secondary probe-detection task, where participants read a passage twice and the length of time for the second reading was measured. Such a method is required to assess actual cognitive load for further analysis. Second, this study used one reading passage, and the reading rate of the recording during the listening-while-reading group was not controlled. Therefore, the additional research with different reading texts and reading rates are needed. Finally, this study adopted reading-mode condition as a between-group design to reduce participants' burden. Future research should compare how learners perceive cognitive load for all three reading modes and how their perception and comprehension change by using within-group and a longitudinal design.

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References


### Appendices

**Appendix A**

**Reading Passage: Money helps teacher**

Students have to take tests every year to see how much they are learning. Some schools do not do very well on these tests. It can be hard for teachers to see their students not do well. Many teachers at these low-performing schools get frustrated and quit. Some of them leave to teach at schools where scores are usually higher. Other teachers look for jobs at schools that pay more money.

The leader of California recently signed a bill that he hopes will help struggling schools. The bill will give money to teachers who take classes to learn more about teaching. They will also get more money if they teach in the low-performing schools.

If a teacher is able to make test scores better he might get a bonus. This means that he would get extra money for doing a great job. People hope that this will make teachers want to teach in schools that are not doing as well as others.

The governor of California wants to help low-performing schools do better on these tests. Teachers are needed to help this happen. Many people hope that this extra money will make teachers want to teach at these schools.
Appendix B
Example of Questionnaire on Oral Reading

I: 音読をしながらきほどの文章を読むのがどれくらい難しいと感じましたか。
とても簡単だった 1 2 3 4 5 6 7 とても難しい

II-Q2: 音読すると、集中できましたか。
集中できた 1 2 3 4 5 6 7 集中できなかった

Q3: 音読をすると、単語の意味を捉えながら読めましたか。
読めた 1 2 3 4 5 6 7 読めなかった

Q4: 音読をすると、自分が文章を理解しているかどうかを把握できましたか。
把握できた 1 2 3 4 5 6 7 把握できなかった