Title of the paper:

Reading aloud activity in L2 and cerebral activation

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Abstract

This article explores the cerebral mechanism of reading aloud activities in L2 learners. These activities have been widely used in L2 learning and teaching, and its effect has been reported in various Asian L2 learning contexts. However, the reasons for its effectiveness have not been examined. In order to fill in this gap, two studies using a brain-imaging technique, near-infrared spectroscopy, were conducted in order to determine a cerebral basis for the effectiveness of reading aloud activities. Study 1 investigated learners with high L2 proficiency to show the difference in cerebral activation between L2 and L1 learners as they read a passage aloud. The effect of material difficulty was also examined in this study. Study 2 then examined learners with both high and low L2 proficiency to show the effect of material difficulty vis-à-vis the learners' L2 proficiency. The effect of repeated reading aloud activities was also investigated in this study. These studies show that (a) reading aloud in L2 results in a higher degree of cerebral activation than reading aloud in L1 does; (b) reading material beyond learners' L2 ability aloud results in low brain activation; (c) repetition of the same normal reading aloud activity in L2 does not necessarily increase (or decrease) the level of cerebral activation; however, (d) including a repetitive

cognitively demanding reading aloud activity does cause high brain activation. On the basis of these findings, this article provides a cerebral basis for the effectiveness of reading aloud activities in L2 learning.

Keywords

reading aloud, L1 and L2 reading, brain imaging, psycholinguistic processes, Japanese EFL learners

Background

Reading aloud (RA) has often been reported to be effective in both L1 and L2 learning. For example, with a meta-analysis of 18 studies that investigate the effects of RA interventions for children at risk of L1 reading difficulties, Swanson et al. (2011) found that RA is effective for children's language development, including phonological awareness, print concepts, comprehension, and vocabulary. Some researchers argue that RA can enhance the literacy of not only children but also older students at various stages of schooling (e.g. Sanacore, 1992). In bilingual teaching, RA has also been found to increase language awareness and learner motivation (Lyster et al., 2009).

Shifting our focus to L2 contexts, the literature on RA as a learning/teaching method is as old as the field of L2 research itself (e.g. Cartledge, 1952; West, 1953). However, its use has been constantly discouraged for more than three decades owing to the wider preference of communicative teaching. In the communicative approach, RA is considered an obsolete method that might hinder the development of L2 proficiency (Gabrielatos, 2002; Gibson, 2008).

Despite these criticisms, RA has been widely used in L2 classrooms worldwide,

especially in Asia (Gabrielatos, 2002; Gibson, 2008; Huang, 2010; Kailani, 1998; Kato, 2009). In addition, it has been frequently reported that EFL learners prefer using RA as a learning method. In vocabulary learning, repeatedly reading a target word or sentence aloud, as opposed to silent (mental) repetition, is one of the most frequently employed vocabulary learning strategies (Gu and Johnson, 1996; Mizumoto, 2010; Nyikos and Fan, 2007; Schmitt, 1997; Woore, 2010). In addition, researchers have reported that successful EFL learners use the RA as a learning method frequently (Gibson, 2008; Takeuchi, 2003, 2009). Some empirical studies have found that RA is effective even in the development of EFL proficiency (Miyasako, 2006; Suzuki, 1998) and that RA ability and English proficiency show moderate to strong correlations (Ikeda and Takeuchi, 2002; Miyasako, 2002). These studies suggest that RA is effective in L2 proficiency development.

Some articles have investigated the reasons behind the effectiveness of RA in language learning and have obtained the following results: RA can (a) enhance reading skills by reinforcing graphemic-phonemic correspondences (Stanovich, 1991 cited in Gibson, 2008), (b) build automaticity in the lower-level processes of reading, such as word recognition, and increase reading rates (Kadota, 2007; Taguchi et al., 2006), (c)

facilitate the acquisition of the prosodic features of English (Gibson, 2008), (d) help in the memorization of new information such as vocabulary by activating the working memory (Kadota, 2007), (e) raise language awareness (Lyster, et al., 2009), (f) help in the development of other skills (Gabrielatos, 2002; Gibson, 2008), and (g) reduce speaking anxiety and improve the classroom atmosphere (Gánem-Gutiérrez, 2009; Gibson, 2008; Huang, 2010). In the psycholinguistic view of reading, studies have found that the balanced use of both top-down and bottom-up strategies is important in successful reading (Anderson, 1991, Macaro, 2001, Swan, 2008). Thus, it can be summarized that RA can especially contribute to the development of bottom-up processes in reading, as in findings (a), (b), (c), and (d). In consequence, learners will gain proficiency in other aspects of language learning as well.

Accordingly, it seems reasonable to suggest the following: 'the benefits of RA could outweigh the disadvantages, and that the latter could be mitigated by careful and appropriate use of the activity,' and 'the role of RA in language learning should now be reappraised' (Gibson, 2008, p. 29). However, some strong proponents of communicative teaching may still oppose the use of RA in L2 learning.

As explained above, researchers have theoretically speculated on the reasons for

the effectiveness of RA. However, few studies have empirically investigated these reasons. To our knowledge, a series of studies reported by Kawashima (2002) is one of the few that investigate this topic by using a brain-imaging technique. His studies indicate that RA in L2 activates most areas of the brain, particularly the prefrontal cortex, which is closely related to linguistic processing (Osaka, 2008), and thereby enhances L2 learning. According to Kawashima (2002), among many types of exercises, RA is the one that activates most areas of the brain. Kawashima et al. (2005) attribute its superiority to the fact that 'RA is accomplished by the combination of several cognitive processes, for example, recognition of the visually presented words, conversion to phonological representation from graphic representation of words, analysis of the meaning of words, and control of pronunciation.'

Kawashima's study (2002), however, has several limitations, and thus further research is required. First, although the studies indicate that RA in L1 and in L2 can cause a higher degree of cerebral activation in a larger area of the brain (a phenomenon he construes a sign of learning) than reading the same text silently can; furthermore, the study did not investigate the difference in cerebral activation between reading aloud in L1 and L2. Some researchers have suggested that the difference between L1

and L2 can cause varying degrees of cerebral activation because of the difference in the degree of automaticity in processing associated with each language (e.g. Macaro, 2006). Therefore, it is presumed that the brain is less activated when learners read aloud in L1than when they read aloud in L2.

Second, Kawashima ignored the effect of material difficulty on brain activation. If an individual reads a more difficult passage, her/his brain activation may be higher because of the higher cognitive load. By the same logic, it is possible that no significant activation may be induced when a participant reads aloud an easier L2 material simply because of the automaticity in processing. Third, Kawashima did not take the participants' L2 proficiency into account. Without considering this factor, the relative difficulty of the materials is difficult to determine, which makes it difficult to estimate the actual effect of RA activities.

In this paper, we report two studies which were conducted to address these limitations and to determine a cerebral basis for the effectiveness of reading aloud activities.

Study 1

In study 1, we tested the following two hypotheses by utilizing a brain-imaging technique called the near-infrared spectroscopy (NIRS), also known as 'optical topography':

Hypothesis 1: Reading L2 passages aloud results in higher degrees of cerebral activation than reading L1 passages aloud does.

Hypothesis 2: Reading difficult passages aloud in L2 results in higher degrees of cerebral activation than reading easier passages aloud does.

Method

Participants

Fourteen healthy right-handed volunteers (9 females and 5 males) participated in the study. Written informed consent was obtained from them prior to the experiment. They were advanced Japanese EFL learners with mean TOEIC scores of 936.79 ($SD =$ 57.13). Their ages ranged from 23 to 50 years (mean 39.36 years).

Procedures

The ETG-4000 Optical Topography System (Hitach Medical Co., Japan) with a 52-channel array of optodes was used for NIRS measurements (see Figure 1). Optical topography is a real-time, non-invasive brain-imaging technique with less participant restraint (Figure 2). It covers most of the prefrontal cortex and measures its activation. Brain-imaging studies have reported that the prefrontal cortex is responsible for the functioning of working memory (e.g. Curtis and D'Esposito, 2003). The changes in blood hemoglobin concentrations (oxy-Hb) in the brain were measured by the device while participants read aloud L1 (Japanese) and L2 (English) passages with two levels of difficulty (easy and difficult).

All the procedures in this study and Study 2 reported below followed the principles of the Declaration of Helsinki (World Medical Association, 2008) to protect the participants' rights.

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Figure 1. ETG-4000 Optical Topography System

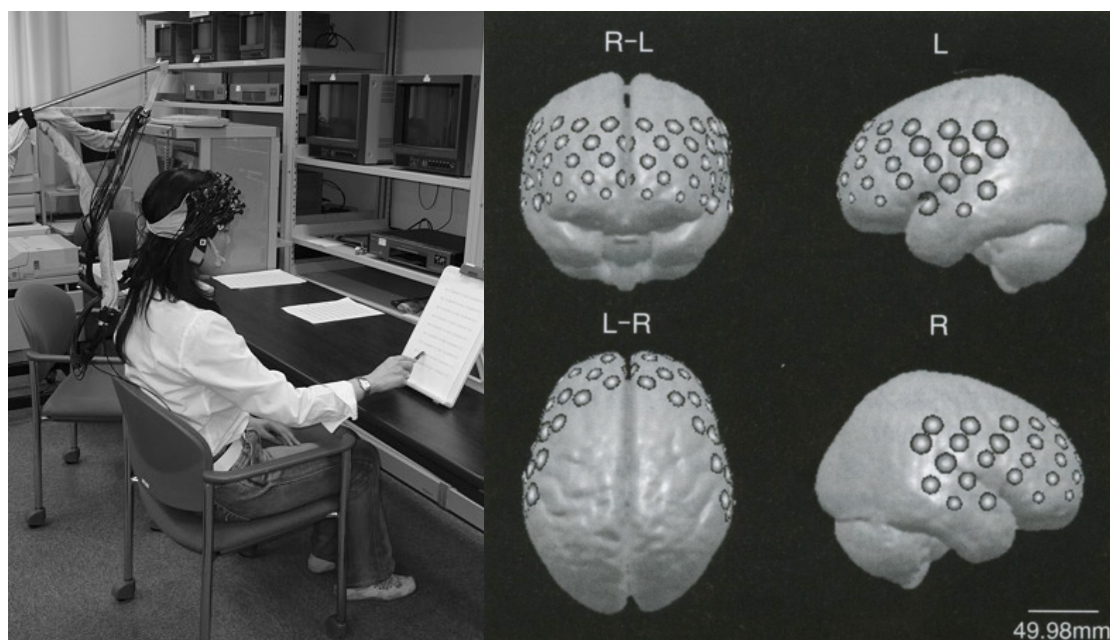Published version: http://rel.sagepub.com/content/43/2/151.abstract

Figure 2. An optical topography device placed on a participant's head (left). Approximate locations of areas covered and measured with a 52-channel NIRS device in the present study (right). Adapted from 'Kinsekigaisen spectroscopy NIRS ni yoru Tougo Shicchoushou to Kanjhoshogai no hojyoshindan' [Near-infrared spectroscopy as a clinical laboratory test for diagnosis and treatment of schizophrenia and mood disorders] by M. Fukuda and M. Mikuni, 2007, Seishin Igaku [Psychiatry], 49, p. 241. Copyright 2007 by Igaku-Shoin. Reprinted with permission.

Since our research hypotheses concerned the type of languages and different levels of task difficulty during RA activities, we asked our participants to read aloud (a) an easy L2 passage, (b) a difficult L2 passage, (c) an easy L1 passage, and (d) a difficult L1 passage. The same participant read these four types of passages. A 30-second rest period (relaxing time) was given before and after each task. During each break, the participant was instructed to relax and silently read a piece of paper that had English letters or Japanese kana syllables (before the English and Japanese tasks respectively). This is a standard procedure for inducing relaxation in brain-imaging research. The order of the conditions was counterbalanced across participants, in order to cancel the effect of the order of task presentation. We then obtained the average concentration of oxy-Hb, a measure of brain activation, for each participant during each RA task.

The difficulty of the materials was checked using readability indexes, and a subjective rating of the difficulty level by the participants at the succeeding interview session confirmed that participants felt that the difficult material was difficult and that the easy one was easy. In addition, the topic of each passage was controlled, so that the participant's background knowledge did not affect the results. The succeeding interview confirmed that the participants felt that they had the same amount of

background knowledge on the topic of each passage.

Table 1

Summary of the Materials for the RA Tasks

Language	Difficulty	Time (seconds)	Topic	Word Count	Readability
English	Easy		Psychology	1,674	11.9
		60			
(L2)	Difficult		Multilingualism	2,687	12.0
Japanese	Easy		Understanding	1,477	9.0
		60	things		
(L1)					
	Difficult		Working memory	1,150	13.0

Note. The readability of the English passages was measured using the Flesch-Kincaid Grade and

that of the Japanese passages, using the Automatic Assessment of Japanese Text Readability

(Sato et al., 2008).

After the experiment, a stimulated recall interview of each participant was conducted to complement the NIRS data. Stimulated recall is a method used to collect learners' insights by presenting them with a stimulus, such as an audio or video recording, and asking them to recall their thoughts during a specific task (Gass and Mackey, 2000). In this study, each participant was shown both the reading material and a video clip of her/him working on each passage, along with the NIRS data (i.e. graphical representation of the changes in blood hemoglobin concentrations) and was then asked to report what she/he was actually thinking or doing during the task. The session was recorded with an IC recorder.

Analyses

To test the hypotheses, we applied a two-way repeated measures ANOVA to oxy-Hb as a dependent variable, with factors of language (L1 and L2) and material difficulty (easy and difficult). Statistical significance was set at the .05 level for all analyses. We also ran post hoc tests involving multiple comparisons with false discovery rate (FDR; Benjamini and Hochberg, 1995) to control the Type I error (i.e. falsely reporting a statistical difference when there is none). Since the sample size in

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this study was relatively small (N = 14), the Type II error rate (i.e. detecting no statistical difference when there is one) may have been substantially inflated and statistical power therefore diminished. In addition, data from small sample sizes often contain outliers. We thus used a robust paired-samples t-test (20% trimmed means and a percentile bootstrapping method) for multiple comparisons (Larson-Hall, 2010; Larson-Hall and Herrington, 2010) and effect sizes (d) for interpretation. All the analyses in Studies 1 and 2 were conducted using R version 2.13.0. The qualitative data obtained from the stimulated recall interviews were coded and used to corroborate the findings in the quantitative analyses.

Results and Discussion

The descriptive statistics of the changes in oxy-Hb concentration in each condition are presented in Table 2. The data is graphically represented in Figure 3. Table 2 and Figure 3 show that cerebral activation was higher when participants read aloud both easy and difficult L2 passages. The standard deviations are large in this study because variability is generally slightly greater in physiological data such as those on brain activity (e.g. Morishita and Osaka, 2008).

The results of the 2×2 (languages and difficulty of materials) repeated measures ANOVA revealed a significant effect of language, ($F[1,13] = 11.809$, $p = .004$, partial $\eta^2 = .476$). The effects of difficulty of materials ($F[1,13] = 0.003$, $p = .960$, partial $\eta^2 < .001$) and interaction ($F[1,13] = 0.023$, $p = .882$, partial $\eta^2 = .002$) were not significant.

Table 2

Descriptive Statistics of the Oxy-Hb Concentration in the RA Tasks

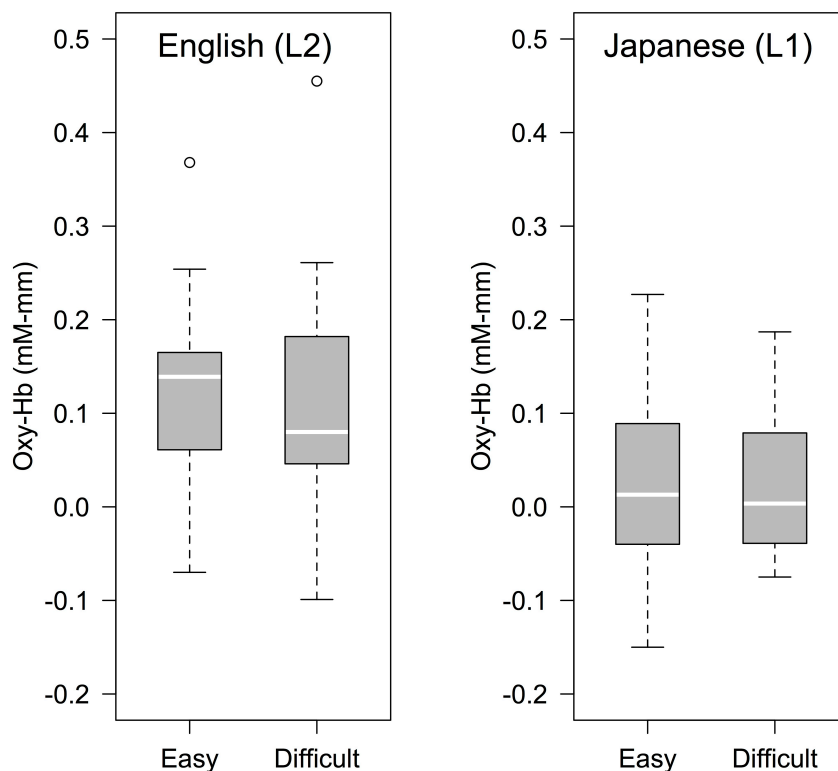| Language	Difficulty	M	SD	95%CI	
				Lower	Upper
English	Easy	0.119	0.115	0.052	0.186
(L2)	Difficult	0.117	0.137	0.038	0.196
Japanese	Easy	0.016	0.099	-0.041	0.073
(L1)	Difficult	0.021	0.080	-0.025	0.067

Figure 3. Boxplots of the data

The results of multiple comparisons are presented in Table 3. The comparisons of easy and difficult passages in the same language [(a) and (b) in Table 3] confirmed that the difficulty level of the passages had no effect. The comparisons of languages at the same difficulty level [(c) and (d) in Table 3] showed higher oxy-Hb concentrations when participants read aloud in L2 than when they read in L1.

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These results corroborate Hypothesis 1, 'Reading L2 passages aloud results in higher degrees of cerebral activation than does reading L1 passages aloud.' However, Hypothesis 2 ('Reading difficult passages aloud results in higher degrees of cerebral activation does than reading easier passages aloud.') is not supported. Contrary to our expectation, the results indicated that reading difficult passages aloud does not result in higher degrees of cerebral activation than reading easier passages aloud does.

Table 3

Results of Multiple Comparisons

Comparison	p	95% CI		d
		Lower	Upper	
(a) English Easy - English Difficult	.961	-0.080	0.082	0.012
(b) Japanese Easy - Japanese Difficult	.769	-0.043	0.034	0.072
(c) English Easy - Japanese Easy	.002*	0.050	0.152	0.940
(d) English Difficult - Japanese Difficult	.012*	0.019	0.169	0.624

Note. The underlined conditions have a higher mean. *$p < .05$ (significant with FDR). The p value is calculated from the robust paired-samples t-test (20% trimmed means and a percentile

bootstrapping method). Accepted criterion (Cohen, 1988) for the effect size (d): $d = 0.20$ (small effect), $d = 0.50$ (medium effect), and $d = 0.80$ (large effect).

Qualitative data from the stimulated recall interviews (see Appendix) suggested that the difficult passages were so tough for the participants to comprehend that they were simply reading what they saw aloud without actually analyzing the passages, which resulted in relatively lower concentration of oxy-Hb.

Summary of Study 1

The results of Study 1 support the hypothesis that reading L2 passages aloud results in higher degrees of cerebral activation than reading L1 passages aloud does. However, we found that if the material was too difficult, the brain activation did not change across materials. The qualitative data imply that the absence of this effect can be attributed to the relatively lower workload caused by the incomprehensibility of the difficult passages. These results suggest that in RA activities the difficulty level of materials is a very important factor.

Study 2

In Study 1, we found that the difficulty level of materials is an important factor in L2 RA activities. The difficulty of the materials, however, is not inherent, but is determined by the proficiency level of L2 readers. We thus believe that the effect of material difficulty should be examined vis-à-vis L2 learner's proficiency.

Another point is that, in L2 classrooms, RA activities are conducted repeatedly and in various ways. To our knowledge, however, no research has determined which sequence of repetition is more effective in terms of brain activation. We expect that the repetition of different types of RA activities will increase cognitive load, thus resulting in higher cerebral activation, than will the simple repetition of the same RA activity. Similarly, simple repetition of the same RA activity may decrease the level of cerebral activation because repetition might facilitate automaticity in processing, thus resulting in lower cerebral activation.

Therefore, in Study 2, we tested the following three hypotheses:

Hypothesis 1: Reading an L2 material aloud at an appropriate difficulty level results in higher degrees of cerebral activation than does reading a material aloud at an inappropriate (i.e. too difficult) level.

Hypothesis 2: Repeating different types of RA activities in L2, which supposedly require more attentional resources and deeper processing of the passages, increases the degree of cerebral activation.

Hypothesis 3: Repeating the same type of RA activity in L2 decreases the degree of cerebral activation.

Method

Participants

Seventeen healthy right-handed volunteers (8 females and 9 males) participated in the study. Their ages ranged from 18 to 48 years (mean 25.94 years). They were categorized into two groups according to their English proficiency: the advanced proficiency group ($n = 8$) and intermediate proficiency group ($n = 9$). The differences in the participants' TOEFL scores (Advanced group $M = 606.25$, $SD = 35.00$; Intermediate group $M = 517.00$, $SD = 26.56$; $t = 5.87$, $p < .001$, effect size $d = 2.90$)

confirmed that the two groups differed with respect to their L2 (English) proficiency.

Procedures

The material for the RA activity was prepared such that the level would be

appropriate for the advanced group. Thus, we expected the material to be very difficult

for the intermediate group. We verified the difficulty of the materials using a

readability index (the Flesch-Kincaid Grade), and the subjective rating of difficulty by

the participants at the interview session confirmed that the material was just

appropriate for the advanced group and too difficult for the intermediate group.

As in Study1, the ETG-4000 Optical Topography System with a 52-channel array

of optodes was used to measure the changes in blood hemoglobin concentrations in the

brain while the participants were performing the RA activities.

Both groups of participants performed two sequences of four RA activities:

Sequence A went as follows: (1) reading aloud normally, (2) reading aloud while

paying attention to the parsed phrases (Slashed), (3) reading aloud while paying

attention to the meaning of the passage (Meaning), and (4) 'reading and looking up'

(reading a phrase silently and then looking up and repeating the same phrase aloud by

memory). The 'read and look up' RA activity is considered to be the most cognitively demanding task of all the repetition tasks because it involves the temporal retention of the phrases in the working memory and articulation of the phrase.

Sequence B was a simple RA task with a single L2 passage that had to be repeated four times (see Table 4). Sequence A was formulated on the basis of classroom activities recommended by the EFL literature in a Japanese context (e.g. Higashitani, 2009; Tsuchiya, 2004). The order of conditions was counterbalanced across participants, thereby cancelling the effect of the order of task presentation. In this article, we refer to Sequence A as 'Elaborate Repetition' because it requires participants to read aloud in a more elaborate way than they are required to in Sequence B, 'Simple Repetition.'

Each task lasted for 120 seconds. A 60-second rest period (relaxing time) was given before and after each task. During each break, the participant was instructed to relax and silently read a piece of paper that had English letters or Japanese kana syllables (before the English and Japanese tasks respectively). The average concentration of oxy-Hb for each participant during each RA task was calculated and used for subsequent analyses.

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Table 4

Sequences of RA Activities

Sequence A (Elaborate)	Sequence B (Simple)
1) Normal RA Activity	1) Normal RA Activity
2) Reading Aloud while Paying Attention to the Parsed Phrases (Slashed)	2) Normal RA Activity
3) Reading Aloud while Paying Attention to the Meaning of the Passage (Meaning)	3) Normal RA Activity
4) 'Reading and Looking up' Activity	4) Normal RA Activity

We then compared the average blood hemoglobin (oxy-Hb) concentrations between the four conditions: (a) Sequence A by the advanced group, (b) Sequence B by the advanced group, (c) Sequence A by the intermediate group, and (d) Sequence B by the intermediate group.

Analyses

To investigate the hypotheses in the current study, we applied a three-way repeated measures ANOVA to oxy-Hb as a dependent variable, with factors of group (Advanced and Intermediate), sequence (Elaborate Repetition and Simple Repetition), and types of repetition tasks (those presented in Sequences A and B). Statistical significance was set at the .05 level for all analyses. We also performed a robust paired-samples *t*-test (20% trimmed means and a percentile bootstrapping method) for multiple comparisons. As in Study 1, since the sample size was small, we interpreted the results using effect sizes (*d*) in addition to statistical tests to avoid Type II error.

Results and Discussion

Table 5 presents the descriptive statistics of the blood concentration during each RA task. The data is graphically represented in Figure 4.

Table 5

Descriptive Statistics of the Oxy-Hb Concentration During the Tasks

Sequence	Order	Repetition Task	Advanced (*n* = 8)		Intermediate (*n* = 9)	
			M	*SD*	*M*	*SD*
(A) Elaborate Repetition	1	Normal	0.311	0.157	0.092	0.249
	2	Slashed	0.167	0.132	0.038	0.169
	3	Meaning	0.153	0.110	0.035	0.102
	4	Read & Look Up	0.353	0.206	0.099	0.160
(B) Simple Repetition	1		0.258	0.246	0.053	0.138
	2	Normal	0.113	0.141	0.013	0.167
	3		0.155	0.129	-0.002	0.150
	4		0.186	0.256	0.017	0.125

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Table 6

Summary of Three-way Repeated Measures ANOVA

Source	SS	df	MS	F-ratio	p-value		partial η^2
Group	0.965	1	0.965	8.545	0.011	*	0.363
Sequence	0.110	1	0.11	2.706	0.121	ns	0.153
Group×Sequence	0.004	1	0.004	0.101	0.755	ns	0.007
Task	0.261	3	0.087	8.377	< 0.001	*	0.358
Group×Task	0.065	3	0.022	2.09	0.115	ns	0.122
Sequence×Task	0.056	1.91	0.029	1.132	0.334	ns	0.070
Group×Sequence×Task	0.017	1.91	0.009	0.334	0.709	ns	0.022

Note. $^*p < .05$

The results of the three-way repeated measures ANOVA (Table 6) revealed a significant main effect of group (Advanced vs. Intermediate) and that of task (types of repetition tasks). These results indicate that cerebral activation was higher for the

advanced group and the brain activation changed according to the type of repetition. The former result supports Hypothesis 1, 'Reading an L2 material at an appropriate difficulty level aloud results in higher degrees of cerebral activation than does reading a material at an inappropriate level aloud.' Figure 4 shows that, in all repetition tasks, the advanced group had higher hemoglobin concentrations than the intermediate group did.

As explained above, for the advanced group, the level of the material was appropriate, which contributed to higher degrees of brain activation. The degree of cerebral activation was lower in the intermediate group, most probably because the material was rather difficult for the intermediate group participants to understand completely. The average oxy-Hb concentration for the intermediate group in Study 2 was about the same as the mean concentrations of the advanced learners in Study 1 when they read easy or difficult passages aloud in L2 (see Table 2). Thus, we can posit that, when learners read aloud L2 passages that are not at the appropriate difficulty level (i.e. too difficult), the level of their cerebral activation is not as high as that when they read aloud L2 passages at the appropriate level.

The results of multiple comparisons are presented in Table 7. Hypothesis 2,

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'Repeating different types of RA activities in L2, which supposedly require more attentional resources and deeper processing of the passages, increases the degree of cerebral activation,' was partially supported only when the task was cognitively demanding like in the 'reading and looking up' activity. As Figure 4 and Table 6 demonstrate, reading aloud while paying attention to the parsed phrases (Slashed) or reading aloud while paying attention to the meaning of the passage (Meaning) did not bring about an increase in brain activation. However, when the advanced group was engaged in the 'reading and looking up' activity in the Elaborate Repetition (Sequence A), the brain activation increased (see comparison 3 - 4 in Table 7). A similar pattern, though not statistically significant with a medium effect size ($d = 0.52$), was found in the intermediate group's performance of the 'reading and looking up' activity in the Elaborate Repetition (comparison 3 - 4). The differences between the groups with regard to the degree of cerebral activation can be attributed to the differences in the appropriateness of task difficulty (reported above in relation to Hypothesis 1).
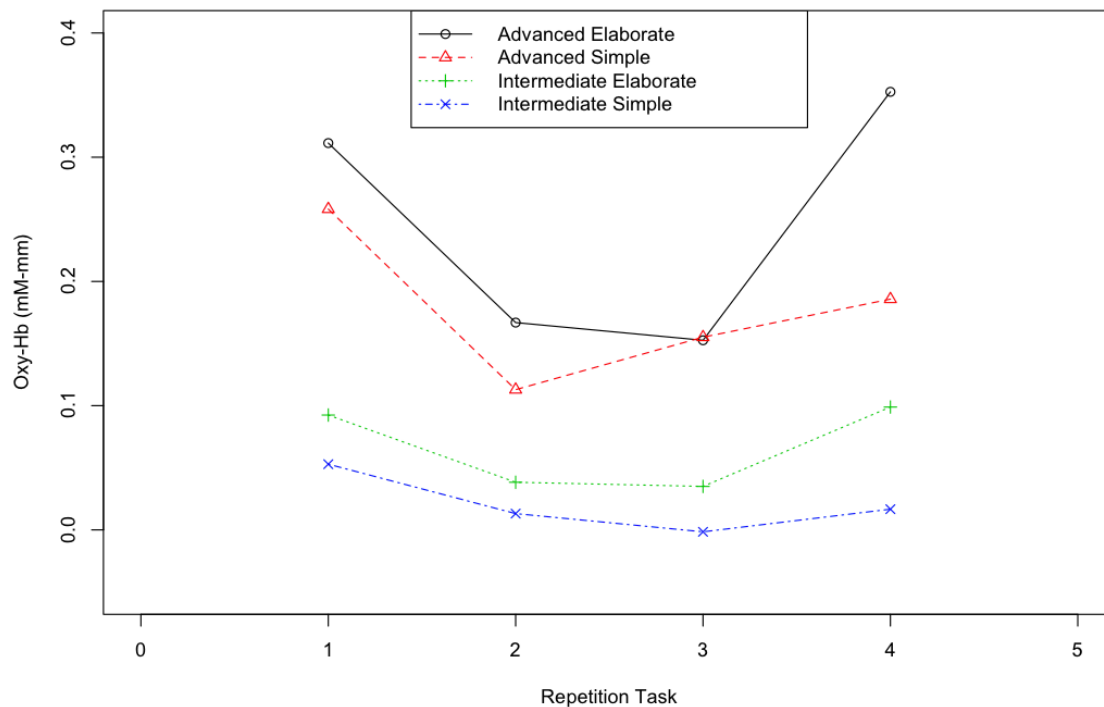
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Figure 4. Graphical representation of the data. See Table 5 for the tasks.

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Table 7

Results of Multiple Comparisons

Comparisons of Repetition	Advanced (*n* = 8)				Intermediate (*n* = 9)			
	Elaborate		Simple		Elaborate		Simple	
	p	*d*	*p*	*d*	*p*	*d*	*p*	*d*
1 - 2	*	1.30	ns	0.72	ns	0.26	ns	0.35
1 - 3	*	1.04	ns	0.45	ns	0.26	ns	0.57
1 - 4	ns	0.22	ns	0.28	ns	0.02	ns	0.31
2 - 3	ns	0.12	ns	0.53	ns	0.04	ns	0.19
2 - 4	ns	0.87	ns	0.45	ns	0.53	ns	0.05
3 - 4	*	1.07	ns	0.16	ns	0.52	ns	0.29

Note. $^*p < .05$ (significant with FDR). The *p* value is calculated from the robust paired-samples

t-test (20% trimmed means and a percentile bootstrapping method). The criteria for effect size

(*d*) are as follows: $d = 0.20$ (small effect), $d = 0.50$ (medium effect), and $d = 0.80$ (large effect).

With regard to Hypothesis 3, the results of multiple comparisons reported in Table

7 suggest that simple repetition of the same type of RA activity (Sequence B) does not

decrease, but instead maintains, the degree of cerebral activation. The decrease in cerebral activation was observed only at the beginning, from the first time to the second (comparison 1 - 2). Furthermore, this pattern was only observed in the advanced group and not in the intermediate group. Therefore, we rejected the hypothesis. We expected the simple repetition of the same RA activities to decrease the level of cerebral activation because repetition would probably facilitate automaticity in processing, thus resulting in lower cerebral activation. This was not the case in this study. However, several repetitions of the same RA activity could have decreased cerebral activation. This remains to be explored.

Summary of Study 2

In Study 2, we examined the effect of material difficulty (vis-à-vis the learner's L2 proficiency) and that of the repetition of RA activities. The results demonstrate the following: (a) reading a material at an appropriate difficulty level aloud results in a higher degree of cerebral activation than reading a material at an inappropriate level aloud does; (b) repeating different types of RA activities in L2 increases the degree of cerebral activation only when the task is cognitively demanding; and (c) repeating the

same type of RA activity does not decrease (or increase) the degree of cerebral activation.

Conclusion and Implications

This article aimed at exploring the cerebral mechanism of the effectiveness of RA activities in L2 learning. Two empirical studies were reported to clarify the roles of language (L1 or L2), material difficulty, and types of repetition in RA activities by focusing on the activation of the prefrontal cortex, measured using the brain-imaging technique, NIRS.

There are two limitations of the current studies that should be acknowledged. First, the sample sizes were limited in both studies. Further studies, therefore, are needed to generalize the findings of the two studies. Second, the relationship between vocabulary size and reading comprehension was not well considered in the reading aloud tasks of the two studies. Past research has shown that vocabulary size is a reliable predictor of reading comprehension (Zhang & Annual, 2008). Although the difficulty levels and topics of the materials were controlled in the current studies, considering the

importance of vocabulary size in reading comprehension, it was also necessary to control the vocabulary levels of the texts because it might have played a role in affecting the participants' successful or unsuccessful reading aloud.

With there limitations in mind, from our studies, we found that (a) reading aloud in L2 results in a higher degree of cerebral activation than reading aloud in L1does, (b) the material difficulty level greatly influences the effects of RA activities (i.e. if the given material is at the appropriate difficulty level, cerebral activation is higher), (c) repetition of the same RA activity neither increases nor decreases blood hemoglobin concentrations, but (d) the increase in blood hemoglobin concentrations can be observed when learners are engaged in a repetitive cognitively demanding L2 RA activity.

Our findings have two pedagogical implications. First, L2 teachers as well as learners need to pay more attention to the difficulty level of the materials in L2 RA activities. To maximize the RA effect, they should select materials that are appropriate in terms of difficulty vis-à-vis the learners' L2 proficiency. Second, L2 teachers and learners cannot expect the simple repetition of the same RA activity to be very effective. While selecting RA activities, they are advised to choose those that are

inherently elaborate and cognitively demanding. Repetition of the same RA activity should be avoided especially when doing so serves no reasonable purpose.

A number of past studies suggest that RA is effective for the improvement of L2 proficiency. In this article, we have offered a cerebral basis for this effectiveness. In L2 learners, RA can result in brain activation, which is a sign of learning, according to Kawashima (2002). Thus, RA can be recommended as a good L2 learning/teaching practice, especially in the Asian L2 learning contexts, where RA has traditionally been used and approved.

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References

Anderson NJ (1991) Individual differences in strategy use in second languid reading and

testing. *The Modern Language Journal* 75(4): 460–472.

Benjamini Y and Hochberg Y (1995) Controlling the false discovery rate: A practical and

powerful approach to multiple testing. *Journal of the Royal Statistical Society Series B*

57(1): 289–300.

Cartledge HA (1952) Reading aloud. *ELT Journal* 6(3): 94–96.

Cohen J (1988) *Statistical Power Analysis for the Behavioral Sciences* (2nd ed.). Hillsdale, NJ:

Lawrence Erlbaum.

Curtis CE and D'Esposito M (2003) Persistent activity in the prefrontal cortex during working

memory. *Trends in Cognitive Sciences* 7(9): 415–423.

Gabrielatos C (2002) Reading loud and clear: Reading aloud in ELT. Retrieved from ERIC

database. Available at: http:// http://www.eric.ed.gov/PDFS/ED477572.pdf

Gass SM and Mackey A (2000) *Stimulated Recall Methodology in Second Language Research*.

Mahwah, NJ: Lawrence Erlbaum.

Gibson S (2008) Reading aloud: A useful learning tool? *ELT Journal* 62(1): 29–36.

Gu PY and Johnson RK (1996) Vocabulary learning strategies and language learning outcome.

Language Learning 46(4): 643–679.

Gánem-Gutiérrez GA (2009) Repetition, use of L1 and reading aloud as meditational mechanism during collaborative activity at the computer. *Computer Assisted Language Learning* 22(4): 323–348.

Huang L (2010) Reading aloud in the foreign language teaching. *Asian Social Science* 6(4): 148–150.

Ikeda M and Takeuchi O (2002) Reading aloud: An indicator of integrative ability of EFL. *LET Kansai Chapter Collected Papers* 9: 23–30.

Kadota S (2007) *Science of Shadowing and Reading Aloud*. Tokyo: Cosmopia.

Kailani TZ (1998) Reading aloud in EFL revisited. *Reading in a Foreign Language* 12(1): 281–294.

Kato S (2009) Suppressing inner speech in ESL reading: Implications for developmental changes in second language word recognition processes. *Modern Language Journal* 93(4): 471–488.

Kawashima R (2002) *Reading, Writing, and Arithmetic Foster Children's Brain.* Tokyo: Kodomo no Mirai sha.

Kawashima R, Okita K, Yamazaki R, et al.(2005) Reading aloud and arithmetic calculation

improve frontal function of people with dementia. *Journal of Gerontology: Medical Sciences* 60A(3): 380–384.

Larson-Hall J (2010) A guide to doing statistics in second language research using R. Available at: http://cw.routledge.com/textbooks/9780805861853/guide-to-R.asp

Larson-Hall J and Herrington R (2009) Improving data analysis in second language acquisition by utilizing modern developments in applied statistics. *Applied Linguistics* 31(3): 368–390.

Lyster R, Collins L, and Ballinger S (2009) Linking languages through a bilingual read-aloud project. *Language Awareness* 18(3–4): 366–383.

Macaro E (2001) *Learning strategies in foreign and second language classrooms*. London: Continuum.

Macaro E (2006) Strategies for language learning and for language use: Revising the theoretical framework. *The Modern Language Journal* 90(3): 320–337.

Miyasako N (2003) What relationships does metacognition of oral reading have with oral reading ability and English ability for Japanese senior high school students? *Language Education & Technology* 40: 121–140.

Miyasako N (2006) Effects of oral reading practice on reading comprehension of Japanese

learners of English as a foreign language. Unpublished PhD dissertation, Hyogo University of Teacher Education, Japan.

Mizumoto A (2010) *Exploring the Art of Vocabulary Learning strategies: A Closer Look at Japanese EFL University Students.* Tokyo: Kinseido.

Morishita M and Osaka N (2008) Information processing and working memory capacity in linguistic working memory tasks. In: Osaka N (Ed.) *Neural Correlates of Working Memory* (pp. 123−158). Kyoto: Kyoto University Press.

Nyikos M and Fan M (2007) A review of vocabulary learning strategies: Focus on language proficiency and learner voice. In: Cohen A and Macaro E (eds) *Language Learning Strategies: Thirty Years of Research and Practice.* Oxford: Oxford University Press, 251−274.

Osaka N (Ed.) (2008) *Neural Correlates of Working Memory*. Kyoto: Kyoto University Press.

Sanacore J (1992) Reading aloud: A neglected strategy for older students. Retrieved from ERIC database. Available at: http://www.eric.ed.gov/PDFS/ED367971.pdf

Sato S, Matsuyoshi S, and Kondo Y (2008) Automatic assessment of Japanese text readability based on a textbook corpus. *Proceedings of the 6th International Conference on Language Resources and Evaluation (LREC).* Available at:

http://www.lrec-conf.org/proceedings/lrec2008/pdf/165_paper.pdf

Schmitt N (1997) Vocabulary learning strategies. In: Schmitt N and McCarthy M (eds) *Vocabulary: Description, Acquisition and Pedagogy*. Cambridge: Cambridge University Press, 199–227.

Stanovich KE (1991) Changing models of reading and reading acquisition. In Rieben L and Perfetti CA (eds) *Learning to read: Basic research and its implications*. Hillsdale, NJ: Lawrence Erlbaum Associates, 19–31.

Suzuki J (1998) A reprisal of reading aloud: An empirical study on the effectiveness of reading aloud. *LET Kansai Chapter Collected Papers* 7: 13–28.

Swan M (2008) Talking sense about learning strategies. *RELC Journal* 39(2): 262–273.

Swanson E, Vaughn S, Wanzek J, et al. (2011) A synthesis of read-aloud interventions on early reading outcomes among preschool through third graders at risk for reading difficulties. *Journal of Learning Disabilities* 44(3): 258–275.

Taguchi E, Gorsuch GJ, and Sasamoto E (2006) Developing second and foreign language reading fluency and its effect on comprehension: A missing link. *The Reading Matrix* 6(2): 1–18.

Takeuchi O (2003) What can we learn from good language learners?: A qualitative study in the

Japanese foreign language context. *System* 31(3): 385–392.

Takeuchi O (2009) Learning from good language learners in a specific context. In: Yoshida T et al. (eds) *Researching Language Teaching and Learning: An Integration of Practice and Theory*. Oxford: Peter Lang, 305–322.

West M (1953) The technique of reading aloud to a class. *ELT Journal* 8(1): 21–24.

Woore R (2010) Thinking aloud about L2 decoding: An exploration of the strategies used by beginner learners when pronouncing unfamiliar French words. *Language Learning Journal* 38(1): 3–17.

World Medical Association. (2008) *World Medical Association Declaration of Helsinki: Ethical Principles for Medical Research Involving Human Subjects*. Available at: http://www.wma.net/en/30publications/30ethicsmanual/index.html

Zhang LJ and Anual S (2008) The role of vocabulary in reading Comprehension: The case of secondary school students learning English in Singapore. *RELC Journal* 39(1): 52–77.

Appendix

Excerpts from the transcripts of the stimulated recall interviews (brackets and translations are inserted by the authors)

I could read aloud the easy English passage very smoothly. I read it aloud in the same way I did the Japanese ones. Still, I was able to catch the meaning of the passage. But reading the difficult English passage aloud was difficult. I was only able to catch the key words, and I think my attention was rather put on vocalization of the words.

[Participant LJ]

It was very difficult to read the (difficult English) passage aloud. I tried to get its meanings but I couldn't, because I was reading aloud and paying more attention to pronouncing each word properly. [Participant IL]

I didn't understand the meanings of the (difficulty English) passage very well. I tried to in the middle of the passage, but I gave up, because the length of each word was getting longer and I had to concentrate just on vocalization of the passage...

[Participant LT]