



The Impact of Information Processing Styles in Mobile-Assisted Language Learning: Are Multimedia Materials Effective for Every Learner?

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Abstract

This study examines the impact of learners' information processing styles in learning English as a foreign language (L2) within multimodal environments. Simultaneous knowledge representation with verbal and visual annotations has been regarded as an effective way of retaining knowledge and it has been verified by various studies in different settings. However, this study claims that the manipulation of images for successful L2 learning depends on learners' tendencies in processing knowledge with imagery: viz., whether they are high imagers or low imagers. Thus, this study investigates the impact of learners' information processing styles by developing two types of mobile-based applications to learn phrasal verbs. One application consists of sample sentences and images depicting the prototypical senses; the other consists of the sentences and their prototypical senses described verbally. From the results of fill-in-the-blank tests conducted one and two weeks after the treatment, it was found that the use of images accelerated the process of arriving at the correct answers whereas low-imagers processed knowledge better with the verbally oriented application than with the image-oriented application. These findings suggest that successful L2 learning requires multimodal knowledge representation and may be enhanced by materials that differ according to learners' cognitive styles.

1 Introduction

It has been assumed that the advantage of L2 learning materials lies primarily in knowledge representation under multimedia environments; the L2 materials available on personal computers or mobile devices can display not only verbal information, but also visual information concurrently. This has strong theoretical support from Dual-coding theory (Paivio, 1971) and the generative theory of Multimedia Learning (e.g., Mayer & Sim, 1994; Mayer, 2001), which state that presenting information in both verbal and visual modes results in longer knowledge retention than the usage of a single code. Moreover, the findings of previous empirical studies demonstrated the advantage of multimodal knowledge representation for longer retention. (e.g., Boers & Lindstromberg, 2008; Sato & Suzuki, 2010; Sato, Lai & Burden, 2014). These theoretical and empirical examinations might reinforce the over-preference for multimedia in L2 learning. Due to the nature of multimodal

knowledge presentation, recent L2 learning materials contain not only languages and still pictures, but also sounds or animations.

Despite the advantages of multimedia learning, our present study claims that the advantages of multimedia L2 learning could not be gained by EVERY L2 learner. This is based on our large-scale empirical study conducted in Japan and Taiwan (Sato, Lai & Burden, 2014), which demonstrates that the computer-enhanced visual aids for learning L2 prepositions does not lead to better learning effects compared to the visual aids with plain pictorial aids, whereas significant differences were obtained after dividing the participants in terms of their individual differences. Thus, this study will conduct further examination of the impact of individual factors in L2 vocabulary learning.

1.1 Individual factors in multimodal L2 learning

The impact of individual factors has been emphasized in the field of not only L2 acquisition research (e.g., Dörnyei, 2009; Ehrman, Leaver, & Oxford, 2003; Robinson, 2001, 2002; Skehan, 1991), but also multimedia learning (e.g., Mayer, 2001; Moreno, & Durán, 2004). On the other hand, there are few multimedia L2 learning studies which conducted empirical research to examine the impact of such factors. This is probably because the previous studies (e.g., Chun, & Plass, 1996; Yeh, & Wang, 2003; Yoshii, 2006; Sato, & Suzuki, 2010) focused too much on the merit of the integration of verbal and visual information, whereas they paid less attention to the individual factors. This study, therefore, presumes the individual factors based on an individual difference principle (Mayer, 2001; Mayer & Moreno, 2003), may affect L2 learners' language processing when multimodal treatments are employed.

The individual difference which this study addresses pertains to learners' information processing styles. Learners who might be better at conceptualizing knowledge with the help of visual information are called imagers (or high imagers), whereas those who are better at analyzing knowledge through verbal information are called verbalizers (or low imagers) (e.g. Boers & Littlemore, 2000; Riding & Rayner, 1998). Alternatively, they are called imagers or verbalizers (Riding & Rayner, 1998) respectively. According to Mayer & Moreno (2003), learners with high spatial ability acquired higher learning effect than those with low spatial ability under a multimodal environment. Sato, Lai & Burden (2014) also show that the L2 imagers could make better use of multimodal L2 materials both in comprehension and production tasks. The findings trigger our further research question of what knowledge representation is preferable for L2 verbalizers. In this study, therefore, two new multimodal materials are developed to learn L2 phrasal verbs.

1.2 Phrasal verbs

Phrasal verbs (PVs), such as *break in* or *come out*, refer to multi-word units consisting of verbs and particles such as prepositions or adverbs "with a certain amount of idiomaticity, which means that the whole of the phrasal verb has a meaning which is more than a sum of its parts (Dirven, 2001, p. 5)." PVs are historically distinguished from other multi-word units based on their syntactic features: the capability of paraphrasing them into a single word and of separating particles from verbs such as post-verbal particles or post-direct-object particles (e.g., pick up a pencil / pick the pencil up, from Dirven, 2001, p. 4). Meanwhile, they are also distinguished in terms of their semantic features, such as entailing literal and figurative meanings (Gardner & Davis, 2007). Dirven (2001) illustrates that the particles of PVs (e.g., on / in / out / over) are multifunctional words which can function as adverb and preposition as well as implicate one or more dimensional spaces, both of which lead to the extension of their meanings from literal domains to figurative domains.

In the field of second language learning research, PVs have been regarded as difficult to learn (e.g., Boers, 2000; Littlemore & Low, 2006; Nassaji & Tian, 2010; Garnier & Schmitt, 2015; 2016; Yasuda, 2010). This is because PVs consist of two polysemous words with 5.6 meanings on average (Gardner & Davis 2007) and therefore they are regarded as "[o]ne of the most challenging features of English language" (Garnier & Schmitt 2016, p. 30). Due to such semantic complexity, L2 learners

tend to avoid using PVs, especially those with figurative meanings (Liao & Fukuya, 2002) in their spoken or written discourses. Although several studies identified the most frequent PVs in various discourses (e.g., Gardner & Davies, 2007; Garnier & Schmitt, 2015; Liu, 2011), learning PVs still entails difficulty especially with respect to comprehending their meanings.

Despite such difficulties, PVs tend to be recognized as idioms or chunks which can be acquired only by memorization (Lindstromberg, 2001), without much consideration of the semantic complexity. As a result, L2 learners very often find it difficult to use PVs appropriately or to identify which sense of a PV should be used in a certain context.

1.3 Pedagogies for successful PV learning

PVs are of interest not only to linguists but also researchers of L2 learning and teaching (Alejo-González 2010). The semantic complexity of PVs intrigues linguists, especially those operating in the field of cognitive linguistics (CL). For example, several CL studies attempted to elucidate their complex semantic networks in a consistent manner (e.g., Dirven 2001; Rice 2003; Rudzka-Ostyn, 2003).

Furthermore, such analyses based on CL have been applied to L2 vocabulary acquisition, especially when meaning is focused (Boers, 2013) in CL-based instruction on articulating semantic relationships between literal meanings and abstract ones, facilitating the cognitive engagement of the target knowledge and leading to deeper information processing. Many studies have reported the positive effects of such L2 instruction and materials (e.g., Boers, 2000; Boers & Lindstromberg, 2008; Chen, 2009; Cho, 2010; Csabi, 2004; Littlemore, 2009; Morimoto & Loewen, 2007; Sato, 2016a, b; Sato & Suzuki, 2010; Sato, Lai, & Burden 2014; Yasuda, 2010).

For example, one of the CL concepts applied to L2 vocabulary acquisition research is image schema (e.g., Johnson, 1987; Lakoff, 1987; Lakoff & Johnson, 1980), which is the pattern of our bodily experiences. As shown in Figure 1, the image schema is often represented as a form of a visual image (Lakoff, 1987; Dewell, 2004; Tyler & Evans, 2003). CL claims that the image schema systematically connects all meanings of a word (Langacker, 1987).

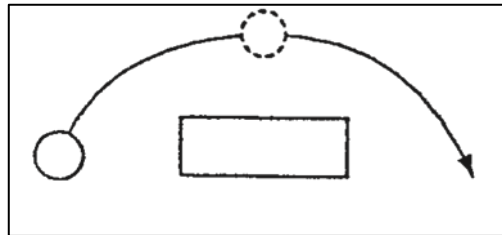


Fig. 1. Example of the cognitive-linguistics-based image schema of the preposition *over* (Dewell, 1994).

As CL employs the visual image to analyze the semantic network of a word, it could function as theoretical support to develop multimodal L2 materials where visual and verbal information are spontaneously displayed. Sato & Suzuki (2010), for example, modified such image schema into a technology-enhanced visual aid for understanding the literal and figurative meanings of the spatial preposition (see Figure 2). Sato (2016a) illustrated that the image-schema visual aids bring about better comprehension of the spatial prepositions, especially with figurative meanings.

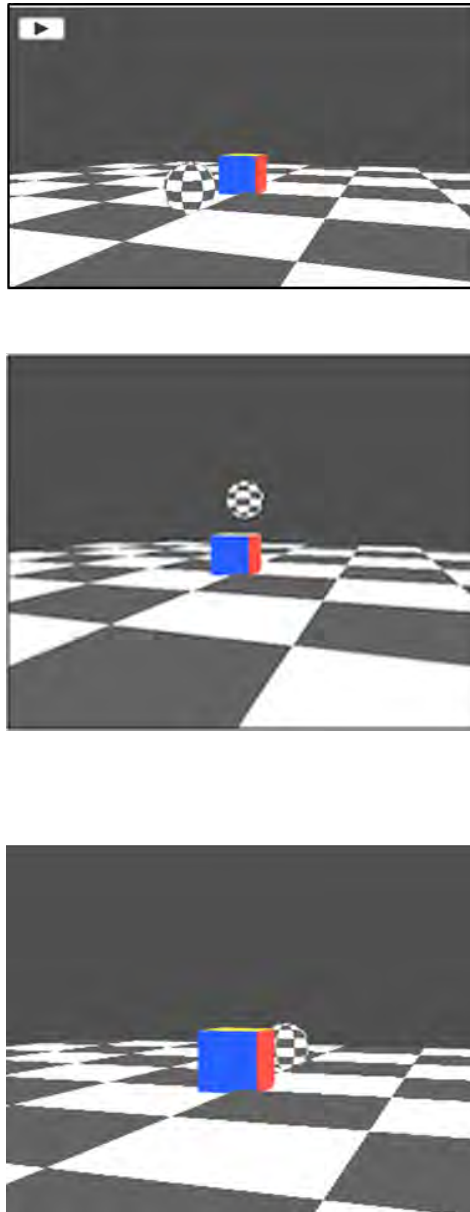


Fig. 2. The image schema of *over* as a visual aid for L2 learning (Sato & Suzuki, 2010)

2 Research study

2.1 Research questions

Given the discussion above, CL-based L2 materials for PV learning using a multimedia environment may bring about positive effects for all L2 learners. To examine the effect, however, our present study claims that another empirical study should be conducted in consideration of an individual factor, i.e., learners' information processing styles. We hypothesized the following research questions (RQs).

1. Do L2 learning materials with visual and verbal aids help Japanese L2 learners to acquire more of the target PVs than they would solely with verbal aids?
2. Do Japanese L2 imagers acquire the PVs more effectively than the verbalizers after they refer to the materials with visual aids?
3. Do Japanese L2 verbalizers acquire the PVs more effectively than the imagers after they use the materials with verbal aids?

2.2 Materials

The learning materials used in this study were developed on Quizlet (<https://quizlet.com>), a web-based tool for learning vocabulary, with which teachers can develop flashcards or fill-in-the-blank questions for the target words with pictorial aids such as images, photos, or graphs. As Quizlet is accessible both from PCs and smartphones, L2 learners can study the words developed by their teacher, irrespective of their location, at their convenience, once they are registered on the site. This study focused on nine verbs (*break, bring, come, give, go, keep, put, run, take*) and three prepositions (*above, on, over*), amounting to eighteen PVs. We firstly selected the particles (*above, on, over*) and then found the verbs which served as PVs with the particles. This prior selection of the particle is on account of the concept that these prepositions refer to similar spatial relations in meaning and the same Japanese translation (*-no ue ni/wo*) is attached to each prototypical meaning, so that it would be difficult for Japanese L2 learners to distinguish them from each other (Sato, Lai, & Tyler, 2014). Since we prepared two sentences for each PV, there are thirty-six questions on Quizlet as seen in Appendix 2. In each question, the learners are expected to fill in the blank in the sentence with a hint provided in a Japanese translation (see Figure 3). In the flash-card mode, for example, they can find the correct answer when they tap the screen.

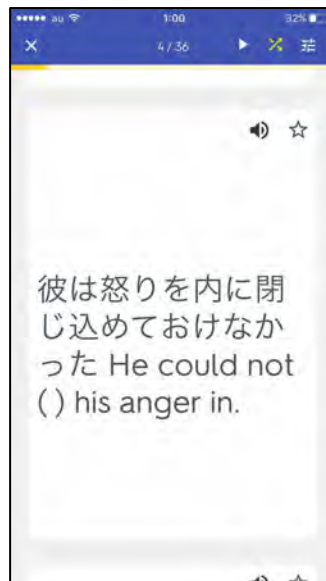


Fig. 3. Example sentence of the materials

This study attached two different types of aids. One is a visual aid which depicts the image-schema-like illustration of each verb and preposition as seen in Figure 4. As the image is based on image schema such as Figure 1, it is not like a picture which describes the situation concretely, but more akin to a conceptual image.

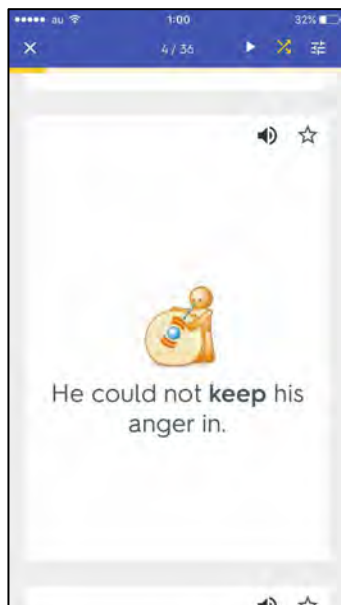


Fig. 4. Example of a visual aid

The other type of aid consists of a verbal explanation of the prototypical meaning of the target word as shown in Figure 5. CL theory (e.g., Langacker, 1987) emphasizes the significance of a prototypical meaning of language since the prototypical meaning will be extended into metaphorical ones, and as a result, each meaning can be cohesively connected by conceptual mapping (Lakoff, 1987). The learners are expected to use the aids in the process of choosing the appropriate verbs or prepositions, whether they are displayed visually or verbally.

As in our research questions, this study hypothesizes that the imagers utilize the visual aids more effectively whereas the verbalizers utilize the verbal aids.

2.3 Participants

Fifty Japanese L2 learners participated in the research. They are all freshmen who belong to the faculty of economics of a private university in Tokyo, Japan. They were randomly divided into a control group ($n=23$) who used the material only with the verbal aids and an experimental group ($n=27$) that used the material with the visual aids. As the average score of the reading section of the TOEIC^R test taken one month before the research (Control group (C): 212.39, Experimental group (E): 216.48) was not statistically different as a result of a t -test ($p=0.25, >0.05$), it can be said that the English language proficiency of each group was standardized. This assured the effect of the L2 materials when any significant difference was found after the treatment.

2.4 Research procedures

The research was conducted in the computer room where the participants' English language lectures were held, so they conducted all the assigned tasks on their computers. First of all, an experimenter asked them to complete the Information Processing Styles Questionnaire (Childers, Houston & Heckler, 1985), consisting of twenty-two statements with a four-point scale. From the results of the questionnaire they were divided into a verbalizer or imager according to their information processing styles. As there was no time limit, every participant could answer all the questionnaire items. Then they answered eighteen fill-in-the-blank questions about the target phrasal verbs as a pretest (see Appendix 1). After the test, the experimenter instructed them about the method to register on

Quizlet and use the materials to learn the PVs made for this research. After a trial using the material for ten minutes, they were told to study the words with Quizlet outside the class for a test to be conducted in the following week. Their learning logs could be observed as a function of teacher modes on Quizlet and they were asked to answer a follow-up questionnaire regarding how often they used Quizlet outside the classroom. As a result, it was found that they had used Quizlet for about ten minutes per day during the week, when they commuted to their university or workplaces, or went back to their home.

One week after, a post-test was held, consisting of twenty-eight questions (see Appendix 3). Half of the questions were from the sentences they learned on Quizlet, while the others were newly developed by the second author of this study. Finally, a delayed test with fifteen questions (see Appendix 4) was conducted one week after the post-test.

As all the tests were developed by *Realtime Evaluation Assistance System (REAS)* (<https://reas2.code.ouj.ac.jp>), their scores on each test as well as the time used to answer all the questions were automatically calculated. Their scores were analyzed by *t*-tests to compare the results between the control and experimental groups, and also by one-way ANOVA and multiple comparison analysis (Fisher LSD) to compare the findings among the four groups (imagers and verbalizers of the control group, and imagers and verbalizers of the experimental group).

3 Findings

The findings of the analyses are shown below. Table 1 shows the average scores and answer time for each group in the pre, post, and delayed test respectively. The results of *t*-tests show there were no significant differences between the groups both in score and time (Score: $p=0.95$, >0.05 ; Time: $p=0.48$, >0.05) in the pre-test. However, in the post-test, a significant difference was found regarding their response time with a medium effect size (Plonsky & Oswald, 2014). (Control group (C): 6.46; Experimental group (E): 6.02) (Score: $p=1.00$, >0.05 ; Time: $p=2.58$, <0.05 , $d=0.75$). In the delayed test, on the other hand, a different finding was noted. Although there was no significant difference in terms of the test score as the previous tests showed, the answer time showed a significant difference between the groups with a large effect size (Score: $p=0.07$, >0.05 ; Time: $p=3.71$, <0.05 , $d=1.09$), which shows that the control group who used the verbal aids shortened their answer time more than the experimental group with the multimodal aids (C: 3.26; E: 4.25).

Table 1. Average score and answer time for each test

	Control Group (n=23)			Experimental Group (n=27)		
	pretest	post test	delayed test	pretest	post test	delayed test
M(SD)	6.74 (1.76)	13.7 (5.02)	8.43 (2.43)	7.22 (1.80)	12.37 (4.36)	8.38 (2.65)
Time(SD)	4.19 (0.49)	6.46 (1.07)	3.26 (0.33)	4.23 (0.36)	6.02 (0.55)	4.25 (1.10)

Next, findings of ANOVA and the multiple comparison are illustrated. The average scores and answer times of the four groups (verbalizers from the control group (C*verb); imagers from the control group (C*image); verbalizers from the experimental group (E*verb); imagers from the experimental group (E*image)) are illustrated in Table 2 below.

As ANOVA for the pretest shows no significant difference among the groups in terms not only of the scores ($F(3,46)=0.78$, $p=0.51$, >0.05) but also of the answer times ($F(3,46)=1.27$, $p=0.29$, >0.05), any differences found in the post or delayed test indicated the effect of the treatment.

The post test showed a different trend. No significant difference was obtained in the score ($F(3,46)=0.83$, $p=0.48$, >0.05) and answer time ($F(3,46)=2.38$, $p=0.08$, >0.05) among the groups, whereas multiple comparison analyses demonstrated that the answer time of the post-test showed a significant difference between the verbalizers with verbal aids and the imagers with visual aids (C*verb: 6.58; E*image: 5.57) ($p=0.03$, <0.05).

As for the delayed test, ANOVA showed no significant difference in the scores ($F(3,46)=0.46$, $p=0.71$, >0.05), but a significant difference was obtained in the answer time ($F(3,46)=5.29$, $p=0.00$,

<0.05). Conducting multiple comparison analyses to find the difference between each group, three significant differences were found in the participants' answer times: between the imagers with verbal aids and the imagers with the visual aids (C*image: 3.18; E*image: 4.37) ($p=0.00$, <0.05); between the verbalizers with verbal aids and the imagers with the visual aids (C*verb: 3.39; E*image: 4.37) ($p=0.02$, <0.05); and finally the imagers with verbal aids and the verbalizers with the visual aids (C*verb: 4.11; E*image: 4.37) ($p=0.02$, <0.05).

Table 2. Average score and answer time of each test in terms of the information processing styles

		Score: M (SD)			Time: M (SD)		
		pretest	post test	delayed test	pretest	post test	delayed test
Control Group	verbalizers (n=8)	6.13 (1.55)	15.13 (5.64)	9.13 (2.90)	4.05 (0.57)	6.58 (0.32)	3.39 (0.34)
	imagers (n=15)	7.17 (1.64)	12.93 (4.68)	8.07 (2.15)	4.24 (0.32)	6.40 (1.20)	3.18 (0.31)
Experimental Group	verbalizers (n=12)	7.07 (1.83)	11.75 (5.51)	8.00 (3.46)	4.35 (0.21)	6.09 (0.53)	4.11 (1.09)
	imagers (n=14)	7.27(1.98)	12.87 (3.29)	8.71 (1.77)	4.13 (0.42)	5.57 (0.58)	4.37 (1.11)

Additional ANOVA and multiple comparison analysis were conducted among the four groups regarding the improvement of their accuracy rate between the pre-and post-test, and between the delayed and post-test (see Table 3). According to ANOVA, no significant differences were obtained in the improvement from pre to post test ($F(3, 46)= 1.55$, $p= 0.21$, >0.05) and from post to delayed test ($F(3, 46)= 1.55$, $p=0.21$ >.05). The results show, however, that a sharp increase of the verbalizers with the verbal aids between pre-and post-test. From the multiple comparison analysis, a significant difference was obtained between the verbalizers with the verbal aids and verbalizers with the visual aids ($p=0.04$, <0.05).

Table 3. Accuracy rate of the average scores between the two tests

	Control: M(SD)		Experimental: M (SD)	
	verbalizers (n=8)	imagers (n=15)	verbalizers (n=12)	imagers (n=14)
post-pre	19.99 (20.47)	6.93 (20.07)	2.15 (17.82)	5.58 (17.42)
post-delay	6.82 (18.77)	7.59 (12.20)	11.37 (15.81)	10.90 (12.12)

4 Discussion

As the present study posed three RQs, we will now answer each of them based on the findings shown above. First of all, RQ1 can be answered in the negative, in terms of the test scores. In other words, our results do not suggest that, overall, L2 learning materials with visual and verbal aids help Japanese L2 learners to acquire more of the target PVs than they would solely with verbal aids. In terms of the answer time, a significant difference was found in the answer time of the post test, indicating a benefit of the multimodal materials. However, this effect was reversed on the delayed test: those who used verbal aids required a shorter answer time than those with visual aids. This might indicate that the learning effect of the visual aids is rather temporary or that traditional verbal aids bring a positive effect in the long run.

Similarly for RQ2, the answer is affirmative only in terms of the answer time for the post-test. After the multiple comparison analysis, a significant difference was obtained between the verbalizers with verbal aids and the imagers with visual aids. This trend might indicate that the visual aids could accelerate the L2 processing of the imagers. In the delayed test, however, the results were reversed. The imagers who used visual aids did not obtain greater effects than the verbalizers who

used verbal aids. Rather, some significant improvements of the answer time were observed in the control group whether they were verbalizers or imagers. As found in RQ1, the findings of RQ2 also indicate that the effect of visual aids are rather temporary and verbal aids could facilitate the information processing, regardless of information processing styles.

Finally, we can answer RQ3 in the affirmative with regard to the answer time for the delayed test and the accuracy rate between the pre- and post-test. The verbal aids could facilitate the verbalizers' information processing, leading to improved PV comprehension.

The findings obtained by this research were rather different from previous studies and our hypotheses. Many studies have found that imagers could exploit imagery-mediated L2 instructions (e.g. Boers et al, 2006; Boers et al., 2008; Littlemore 2004). Our present study, however, illustrated that the efficacy of the visual aids did not last; the efficacy of the verbal aids emerged after the visual effect became less effective. These findings differ from the previous studies related to CL-based L2 learning, but also from our previous studies.

The findings also suggest the importance of the answer time, which few studies have addressed. This is due to the fact that some differences were found in their answer time, but not in their scores. Future studies to address L2 acquisition may focus more on time efficiency as well as score improvement.

5 Conclusion

This study challenged the advantage of multimodal L2 materials that many previous studies examined through their theoretical and empirical research, by hypothesizing that multimodal knowledge representation will bring about better effects for imagers rather than verbalizers, so verbalizers may prefer the traditional knowledge presentation that verbally depicts the concepts of the PVs.

To examine our hypothesis, two kinds of tests were conducted: one is the Information Processing Styles Questionnaire, which can categorize respondents as verbalizers or imagers; the other is fill-in-the-blank tests for the target PVs. The tests were conducted before, one week after, and two weeks after the treatment in which the participants learned the target PVs with mobile-based learning materials on Quizlet. There were two types of materials, one of which consisted only of verbal information, the other of which consisted of verbal and visual information of the target PVs. The scores on each test were collected and then analyzed by *t*-test, one-way ANOVA, and multiple comparison analysis.

Considering that the scores of both groups were improved through using Quizlet, the learning effect of mobile-based L2 materials is confirmed. However, the impact of the visual aids is rather short-term, while that of the verbal aids appears to continue longer, not only for verbalizers but also imagers. In the post test, the participants with the visual aids saved more answer time than those with the verbal aids, but the results of the delayed test were reversed. Similarly, although the post-test answer time of the imagers with the visual aids was significantly shorter than the verbalizers with the verbal aids, the answer time of those with verbal aids in the delayed test became significantly shorter than those with visual aids. Also, the accuracy rate of those with the verbal aids had considerably improved compared with those with the visual aids. In sum, this research brought us several unexpected findings.

So far, our present study could not answer our RQs clearly because our findings are not what were expected. Despite the claim of the previous studies that multimodal functions where verbal and visual information are displayed on one screen have positive effects, our findings might indicate that multimedia functions do not always outperform the traditional ways of explanation. This might warn us not to rely too much on visual aids in L2 learning and teaching (e.g. Boers et al., 2009), although more and more multimedia L2 resources have been released and many teachers and learners are willing to use them. As a result, our present study supports the use of verbal information for acquiring the target L2 knowledge.

This will lead to some pedagogical implications for the L2 material development with multi-modal functions. Considering the better effect of the visual aids in the post-test and of the verbal aids in the delayed test, careful selections of the relevant verbal and visual information and the attempt to integrate them for meaningful learning (Mayer & Moreno, 2002), would enhance L2 processing of both verbalizers and imagers. That is, as L2 instructors and learners, we should be not slaves, but manipulators of advanced technology.

As a matter of course, our study has some limitations when it comes to generalizing our claims. Our research was conducted only in Japan, and the number of participants was not large enough to conduct statistical analyses with four groups. Therefore, our findings regarding RQ2 and RQ3 are less reliable, although our study indicated some trends. To verify a more generalized conclusion towards the impact of the individual factors in multimedia learning, further studies must be conducted with larger samples and different research designs.

References

- Alejo-González, R. (2010). Making sense of phrasal verbs: A cognitive linguistic account of L2 learning. *AILA Review*, 23(1), 50–71.
- Boers, F. (2000). Metaphor awareness and vocabulary retention. *Applied Linguistics*, 21(4), 553–571.
- Boers, F. (2013). Cognitive Linguistic approaches to teaching vocabulary: Assessment and integration. *Language Teaching*, 46(2), 208–224.
- Boers, F., & Littlemore, J. (2000). Cognitive style variables in participants' explanations of conceptual metaphors. *Metaphor and Symbol*, 15(3), 177–187.
- Boers, F., & Lindstromberg, S. (2008). Opening chapter: How cognitive linguistics can foster effective vocabulary teaching. In F. Boers., & S. Lindstromberg. (Eds.) *Cognitive linguistic approaches to teaching vocabulary and phraseology* (pp.1–61), Berlin/New York: Mouton de Gruyter.
- Boers, F., Eyckmans, J., & Stengers, H. (2006). Motivating multiword units: Rationale, mnemonic benefits, and cognitive style variables. *EUROSLA yearbook*, 6(1), 169–190.
- Boers, F., Lindstromberg, S., Littlemore, J., Stengers, H., & Eyckmans, J. (2008). Variables in the mnemonic effectiveness of pictorial elucidation. In F. Boers & S. Lindstromberg (Eds.), *Cognitive linguistic approaches to teaching vocabulary and phraseology* (pp.189–116). Berlin: Mouton de Gruyter.
- Boers, F., Piriz, A. M. P., Stengers, H., & Eyckmans, J. (2009). Does pictorial elucidation foster recollection of idioms? *Language Teaching Research*, 13(4), 367–382.
- Chen, Y. (2009). A cognitive linguistic approach to classroom English vocabulary instruction for EFL learners in mainland China. *English Language Teaching*, 2(1), 95–100.
- Childers, T.L., Houston, M.J., & Heckler, S.E. (1985). Measurement of individual differences in visual versus verbal information processing. *Journal of Consumer Research*, 12, 125–134.
- Cho, K. (2010). Fostering the acquisition of English prepositions by Japanese learners with networks and prototypes. In S. De Knop, F. Boers & A. De Rycker (Eds.), *Fostering language teaching efficiency through cognitive linguistics* (pp. 259–276). Berlin: Mouton de Gruyter.
- Chun, D. L., & Plass, J. L. (1996). Effects of multimedia annotations on vocabulary acquisition. *Modern Language Journal*, 80(2), 183–198.
- Chun, D. L., & Plass, J. L. (1996). Effects of multimedia annotations on vocabulary acquisition. *Modern Language Journal*, 80(2), 183–198.
- Csabi, S. (2004). A cognitive linguistic view of polysemy in English and its implications for teaching. In M. Achard & S. Niemeier (Eds.), *Cognitive Linguistics, second language acquisition, and foreign language teaching* (pp.233–256). Berlin: Mouton de Gruyter.
- Dewell, R. B. (1994). Over again: Image-schema transformations in semantic analysis. *Cognitive Linguistics*, 5(4), 351–380.
- Dirven, R. (2001). English phrasal verbs: Theory and didactic application. In M. Pütz, S. Niemeier, & R. Dirven (Eds.) *Applied cognitive linguistics II: Language pedagogy* (pp. 3–28). Berlin/New York: Mouton de Gruyter.
- Dörnyei, Z. (2009). *The psychology of second language acquisition*. Oxford: Oxford University Press.
- Ehrman, M. E., Leaver, B. L., & Oxford, R. L. (2003). A brief overview of individual differences in second language learning. *System*, 31(3), 313–330.
- Gardner, D., & Davies, M. (2007). Pointing Out Frequent Phrasal Verbs: A Corpus-Based Analysis. *TESOL quarterly*, 41(2), 339–359.
- Garnier, M., & Schmitt, N. (2015). The PHaVE List: A pedagogical list of phrasal verbs and their most frequent meaning senses. *Language Teaching Research*, 19(6), 645–666.

- Garnier, M., & Schmitt, N. (2016). Picking up polysemous phrasal verbs: How many do learners know and what facilitates this knowledge? *System*, 59, 29–44.
- Johnson, M. (1987). *Body in the mind*. Chicago: University of Chicago Press.
- Lakoff, G. (1987). *Woman, fire and dangerous things*. Chicago: University of Chicago Press.
- Lakoff, G., & Johnson, M. (1980). *Metaphors we live by*. Chicago: University of Chicago Press.
- Langacker, R. W. (1987). *Foundations of cognitive grammar: Theoretical prerequisites (Vol. 1)*. Stanford, CA: Stanford University Press.
- Liao, Y., & Fukuya, Y. J. (2004). Avoidance of phrasal verbs: The case of Chinese learners of English. *Language learning*, 54(2), 193–226.
- Lakoff, G. (1987). *Woman, fire and dangerous things*. Chicago: University of Chicago Press.
- Lindstromberg, S. (2001). (Sometimes) Against the grain, *Humanising Language Teaching Magazine*, 3(5), 5.
- Littlemore, J. (2001). Metaphoric competence: A language learning strength of students with a holistic cognitive style? *TESOL Quarterly*, 35(3), 459–491.
- Littlemore, J. (2004). Item-based and cognitive-style-based variation in students' abilities to use metaphoric extension strategies. *IBERICA*, 7, 5–31.
- Littlemore, J. (2009). *Applying cognitive linguistics to second language learning and teaching*. Basingstoke: Palgrave Macmillan.
- Littlemore, J., & Low, G. (2006). Metaphoric competence, second language learning, and communicative language ability. *Applied Linguistics*, 27(2), 268–294.
- Liu, D. (2011). The most frequently used English phrasal verbs in American and British English: A multicorpus examination. *TESOL Quarterly*, 45(4), 661–688.
- Mayer, R. E. (2001). *Multimedia Learning*. Cambridge: Cambridge University Press.
- Mayer, R. E., & Moreno, R. (2003). Nine ways to reduce cognitive load in multimedia learning. *Educational Psychologist*, 38(1), 43–52.
- Mayer, R. E., & Sims, V. K. (1994). For whom is a picture worth a thousand words? Extensions of a dual-coding theory of multimedia learning. *Journal of Educational Psychology*, 86(3), 389–401.
- Moreno, R., & Durán, R. (2004). Do multiple representations need explanations? The role of verbal guidance and individual differences in multimedia mathematics learning. *Journal of Educational Psychology*, 96, 492–503.
- Morimoto, S. & Loewen, S. (2007). A comparison of the effects of image-schema-based instruction and translation-based instruction on the acquisition of L2 polysemous words. *Language Teaching Research*, 11, 347–372.
- Nassaji, H., & Tian, J. (2010). Collaborative and individual output tasks and their effects on learning English phrasal verbs. *Language Teaching Research*, 14(4), 397–419.
- Paivio, A. (1971). *Imagery and verbal processes*. New York: Psychology Press.
- Plonsky, L., & Oswald, F. L. (2014). How big is “big”? Interpreting effect sizes in L2 research. *Language Learning*, 64(4), 878–912.
- Rice, S. (2003). Growth of a lexical network: nine English prepositions in acquisition. In H. Cuyckens, R. Dirven & J. Taylor (Eds.), *Cognitive approaches to lexical semantics* (pp. 243–280). Berlin: Walter De Gruyter.
- Riding, R. & Rayner, S. (1998). *Cognitive styles and learning strategies*. London: David Fulton Publishers.
- Robinson, P. (2001). Individual differences, cognitive abilities, aptitude complexes and learning conditions in second language acquisition. *Second language research*, 17(4), 368–392.
- Rudzka-Ostyn B. (2003). *Word power: Phrasal verbs and compounds. A cognitive approach*. Berlin: Mouton de Gruyter.
- Sato, T. (2016a). Applicability of technology-enhanced visual glosses for explicit L2 vocabulary learning: The enhancement of metaphoric competence through the learning of English polysemous words. *Ampersand*, 3, 43–51.
- Sato, T. (2016b). Could a multimodal dictionary serve as a learning tool? An examination of the impact of technologically enhanced visual glosses on L2 text comprehension. *The EuroCALL Review*, 24(2), 3–12.
- Sato, T., Lai Y., & Burden, T. (2014). Examining the impact of individual differences of information processing styles in technology-enhanced second vocabulary learning. *Proceedings of CLaSIC 2014*, 432–440.
- Sato, T., & Suzuki, A. (2010). Do multimedia-oriented visual glosses really facilitate EFL vocabulary learning? : A comparison of planar images with three-dimensional images. *Asian EFL Journal*, 12(4), 160–172.
- Skehan, P. (1991). Individual differences in second language learning. *Studies in Second Language Acquisition*, 13(2), 275–298.
- Tyler, A., & Evans, V. (2003). *The semantics of English prepositions: Spatial scenes, embodied meaning, and cognition*. Cambridge: Cambridge University Press.
- Yasuda, S. (2010). Learning phrasal verbs through conceptual metaphors: A case of Japanese EFL learners.

TESOL Quarterly, 44(2), 250–273.

Yoshii, M. (2006). L1 and L2 glosses: Their effects on incidental vocabulary learning. *Language Learning & Technology*, 10(3), 85–101.

Vasiljevic, Z. (2015). Effects of etymology and pictorial support on the retention and recall of L2 idioms. *Electronic journal of foreign language teaching*, 12(1), 35–55.

Yeh, Y., & Wang, C. W. (2003). Effects of multimedia vocabulary annotations and learning styles on vocabulary learning. *Calico Journal*, 21(1), 131–144.

Appendix

Appendix 1: Pre-test for L2 phrasal verbs

Questions	Answers
1. Can I come ()?	come over
2. We ran () the coffee shop on the way home.	run in
3. She was so good that her boss kept her ().	keep on
4. () her on, please.	put on
5. He could not () his anger in.	keep in
6. He likes breaking () an animal	break in
7. They took () the company.	take over
8. Teachers have to put feeling () their voice	put in
9. We have to () in a report by Monday.	give in
10. The lecture doesn't () in.	go in
11. The product brought () a big profit	bring in
12. We went () all the reports.	go over
13. I will () over to the prime minister.	give over
14. Let's bring () our next guest.	bring on
15. You should not () on more than you can do.	take on
16. The train is coming ().	come in
17. I will () in every word.	take in
18. Would you () over your point again?	run over

Appendix 2: English phrasal verbs on the application (Quizlet)

Questions	Answers
1. I have to () in my new shoes.	break in
2. He likes breaking () an animal.	break in
3. The product brought () a big profit.	bring in
4. The team decided to () in a new head coach.	bring in
5. This charm will () on happiness.	bring on
6. Let's bring () our next guest.	bring on
7. The train is coming ().	come in
8. She is sure to () in first.	come in
9. A wave of anger comes ().	come over
10. Can I () over?	come over
11. Eventually he gave ().	give in
12. We have to () in a report by Monday.	give in
13. He gave himself ().	give over
14. I will () over to the prime minister.	give over
15. The lecture doesn't () in.	go in
16. I used to go () for football.	go in
17. We went () all the reports.	go over
18. She will () over big.	go over
19. She wants to keep () with musicians.	keep in
20. He could not () his anger in.	keep in
21. She needs to () on with this treatment for another six years.	keep on

22. She was so good that her boss kept her ().	keep on
23. She () in a lot of hours on her report.	put in
24. Teachers have to put feeling () their voice	put in
25. () her on, please.	put on
26. Are you putting me ()?	put on
27. We ran () the coffee shop on the way home.	run in
28. I always () in the new engine before the race.	run in
29. Even though his speech ran (), no one seemed to care.	run over
30. Would you () over your point again?	run over
31. I will () in every word.	take in
32. We took () the sun.	take in
33. You should not () on more than you can do.	take on
34. Her face took () anxious expression.	take on
35. I'll drive the first two hours, and then you () over, OK?	take over
36. They took () the company.	take over

Appendix 3: Post-test for L2 phrasal verbs

Questions	Answers
1. I have to () in my new shoes	break in
2. Are you putting me ()?	put on
3. Eventually he gave ().	give in
4. This charm will () on happiness.	bring on
5. Even though his speech ran (), no one seemed to care.	run over
6. Her face took () anxious expression.	take on
7. She () in a lot of hours on her report.	put in
8. I used to go () for football.	go in
9. We took () the sun.	take in
10. She will () over big.	go over
11. I always () in the new engine before the race.	run in
12. The team decided to () in a new head coach.	bring in
13. I'll drive the first two hours, and then you () over, OK?	take over
14. He gave himself ().	give over
15. She wants to keep () with musicians.	keep in
16. She needs to () on with this treatment for another six years.	keep on
17. She is sure to () in first.	come in
18. A wave of anger comes ().	come over
19. Could you just quickly () over the key points of your report for me please?	run over
20. I'll keep () loving you no matter what you do.	keep on
21. Please wait a minute. I'll just () my coworker on. She can answer your question.	put on
22. She () in for a minute to buy some milk.	run in
23. Strong feelings of guilt and shame () over me.	come over
24. The older students break () the younger students in the school.	break in
25. The story went () big with the children.	go over
26. The TV program was so funny she () herself over to laughter.	give over
27. Trump () in thousands of new members to his political party every week.	bring in
28. While I was on holiday, my coworker () on my work.	take on

Appendix 4: Delayed test for L2 phrasal verbs

Questions	Answers
1. Would you () over your point again?	run over
2. You should not () on more than you can do.	take on
3. The product brought () a big profit	bring in
4. He likes breaking () an animal	break in
5. He gave himself ().	give over
6. () her on, please.	put on
7. I will () in every word.	take in
8. I will () over to the prime minister.	give over
9. We went () all the reports.	go over
10. Her face took () an anxious expression.	take on
11. Can you take () the cooking while I answer the phone?	take over
12. The wet weather always brings () my cough.	bring on
13. I need to () in my English homework soon, otherwise Professor Sato will get angry.	give in
14. When she held my hand I could not keep () my feelings.	keep in
15. To become a good musician you need to () in a lot of practice.	put in
16. He really goes () for computer games.	go in