EFL Learners' Cognitive Load of Learning Vocabulary on Mobile Phones

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Abstract: The present study examined the effects of MMS vocabulary learning and the extent of cognitive load in different multimedia modes. This study of within-subject design recruited 32 eighth graders in central Taiwan to study 36 target words divided into four sets. Each set was presented in one of the four multimedia modes: text, text-audio, text-picture, and text-audio-picture. Immediately after learning each set all participants took a vocabulary test and a cognitive load questionnaire; and, they took a delayed test after two weeks. The results of ANOVA showed no significant differences in vocabulary gains and retention among the four modes, but in cognitive load. The text-audio-picture mode imposed lower load on our adolescents than the text mode and the text-picture mode; also, the text-audio mode induced lower cognitive load on learning than the text mode. Semantic simplicity in the target words and our learners' repeated exposures could contribute to leveling off the differences in vocabulary gains and retention. Audio references, on the other hand, helped our learners associate forms with sounds and enhanced the input from an additional channel. The findings not only supported features of portability and immediacy in mobile learning but also confirmed the modality effect and the temporal contiguity effect of content presentations in multimedia learning.

Keywords: Cognitive load, mobile phones, multimedia messaging service (MMS), multimedia modes, vocabulary learning

1. Introduction

Mobile phones nowadays serve as useful tools for communication and for language learning. The effectiveness of SMS (Short Message Service) vocabulary learning has been widely discussed and confirmed in a number of studies (Cavus & Ibrahim, 2009; Kennedy & Levy, 2008; Levy & Kennedy, 2005; Lu, 2008; Thornton & Houser, 2005, Zhang, Song & Burston, 2011). More recently MMS (Multimedia Messaging Service) messages, involving texts, pictures, audios, and videos, offer an alternative way of vocabulary learning in both mobile and multimedia environments. While multimedia information can be beneficial, learning is likely to be less effective due to limited human cognitive capacity. Based on the Cognitive Load Theory (Pass, Tuovinen, Tabbers, & van Gerven, 2003; Sweller, van Merriënboer, & Pass, 1998), different multimedia presentations of instructional materials may impose various degrees of cognitive load, which could influence the effectiveness of learning. The purpose of the present study is to define the relationship between multimedia presentations and cognitive load in vocabulary learning on cell phones. This issue is addressed in two aspects: vocabulary gains and retention in different multimedia modes, and a comparison of the cognitive load imposed on learners by different multimedia modes.

2. Literature Review

2.1. Vocabulary learning in multimedia and mobile learning environment

Studies on multimedia annotations have been widely conducted to examine their effectiveness. The potentials of multimedia presentations of instructional materials have changed the way learners learning vocabulary. The advantages of encountering target words in versatile multimedia settings benefit language learners in retrieval and generative use. Previous research on multimedia vocabulary annotations supported the dual-coding theory (Paivio, 1986) and the generative theory of multimedia learning (Mayer, 1997). Vocabulary instructional materials presented in both verbal forms (i.e. texts) and visual forms such as pictures (Chun & Plass, 1996; Lin, 2009; Shahrokni, 2009; Yeh & Wang, 2003; Yoshii & Flaitz, 2002; Yoshii, 2006), animations, and videos (Al-Seghayer, 2001; Akbulut, 2007; Plass et al., 1998, 2003) were found to display better facilitative effects on vocabulary learning than in either verbal or visual forms only. Few studies, however, found that texts provided equally sufficient lexical information for vocabulary learning as graphics did (Acha, 2009; Yanguas, 2009).

In the mobile era, using mobile devices in language learning creates an environment without the limitations of time and space. It has extended traditional classroom learning to daily contexts. Mobile phones, compared with other mobile handhelds, have reached the highest penetration rate in most countries, including Taiwan. Considering its availability and small-sized interface, research investigating the potentials of mobile-phone assisted language learning mainly focused their efforts on vocabulary learning. In previous studies (Cavus & Ibrahim, 2009; Kennedy & Levy, 2008; Levy & Kennedy, 2005; Lu, 2008; Stockwell, 2010; Thornton & Houser, 2005, Zhang, Song & Burston, 2011), language learners considered vocabulary learning via mobile phones effective and motivating. Vocabulary lessons delivered through Short Messaging Service (SMS) were welcome among language learners primarily because of their screenful content for learning. As learners in Kennedy and Levy's (2008) study stated, their vocabulary knowledge about English was consolidated and extended in the process of SMS vocabulary lessons. The effects of multimedia annotations for vocabulary learning on cell phones were discussed in terms of their interactions and learners' cognitive processing abilities (Chen et al., 2008; Taki & Khazaei, 2011). For learners with high visual or high verbal abilities, annotations with pictures worked more effectively, while for learners with low cognitive abilities, the basic textual information was conducive to learners (Taki & Khazaei, 2011), and the pictorial one may cause cognitive overload (Chen et al., 2008).

2.2. Cognitive load

Cognitive load on learners varies with different instructional designs of materials and has a great impact on learning performances (Sweller et al., 1998; Pass et al., 2003). It can be classified as intrinsic cognitive load, extraneous cognitive load, and germane cognitive load. The learning information is referred to as the source of intrinsic cognitive load, which is determined by the level of element interactivity, that is, the degree to which the target learning element interacts and refers to other elements. Extraneous cognitive load, usually resulting from non-optimal instructional procedures, refers to the cognitive imposition on learners due to the instructional designs. Unlike intrinsic and extraneous cognitive loads that are related to materials, germane cognitive load concerns more about the use of learners' working memory resources to deal with intrinsic cognitive load. A focus of cognitive load research is to reduce the levels of extraneous cognitive load, which can be modified by various instructional designs (Pass et al., 2003; Sweller, 2010; Sweller

et al., 1998).

Because cognitive load imposed on learners may positively or negatively influence their learning, Mayer and Moreno (2003) proposed important principles for designing multimedia instructional materials, two of which are related to the study. One is the modality effect, which states that when identical learning information is presented via dual modalities, visual and auditory, the capacity of humans' working memory is increased, and the cognitive load is reduced. The other principle is the temporal contiguity effect, indicating that when instructional materials in dual modalities are presented simultaneously, the cognitive load imposed on learners may be decreased.

Previous research on cognitive load on vocabulary learning seldom discussed its impact on learners nor directly measured the load on vocabulary learning. Plass et al. (2003) and Acha (2009), for instance, suggested that learners with low cognitive processing abilities would allocate more cognitive resources to handle pictures or videos. Similarly, Chen et al. (2008) indicated that learners with low cognitive processing abilities would experience cognitive overload when receiving vocabulary learning messages with both texts and pictures. Nevertheless, cognitive load discussed in the above studies was addressed based on learners' performance without further measurement to support their statements. Because learners' processing of information and learning materials are heavily influenced by the cognitive load, understanding how it works and how it is related to the learning outcomes becomes essential, especially in a multimedia learning environment, where various instructional designs can increase or decrease the extraneous cognitive load.

The present study, therefore, aims to evaluate the effectiveness of learning vocabulary with different multimedia annotations on cell phones and to examine the extent of cognitive load of different multimedia modes on learning vocabulary on cell phones.

3. Method

3.1. Participants

Thirty-two eighth graders in central Taiwan were recruited and were considered beginners of English. They had three English classes per week. All participants had their own cell phones and their parents' permissions.

3.2. Materials

Three veteran English teachers selected 36 target words from the word list of the intermediate level of GEPT (General English Proficient Test in Taiwan), including 12 nouns, 12 verbs, and 12 adjectives. Then, the target words were divided into four different multimedia mode groups: the text mode, the text-audio mode (audio), the text-picture mode (picture), and the text-audio-picture mode (combined). Each mode consisted of nine target words, that is, three nouns, three verbs, and three adjectives.

In the text mode, textual information including target words, syntactical categories, Chinese equivalents, and example sentences was offered. Words in the audio mode were presented with textual information and their audio references of target words and example sentences. In the picture mode, textual information and pictures illustrating the target words were provided. Finally, words in the combined mode included text, audio, and picture references. Figure 1 below shows examples of the four presentation modes of MMS vocabulary learning messages on different students' cell phones.

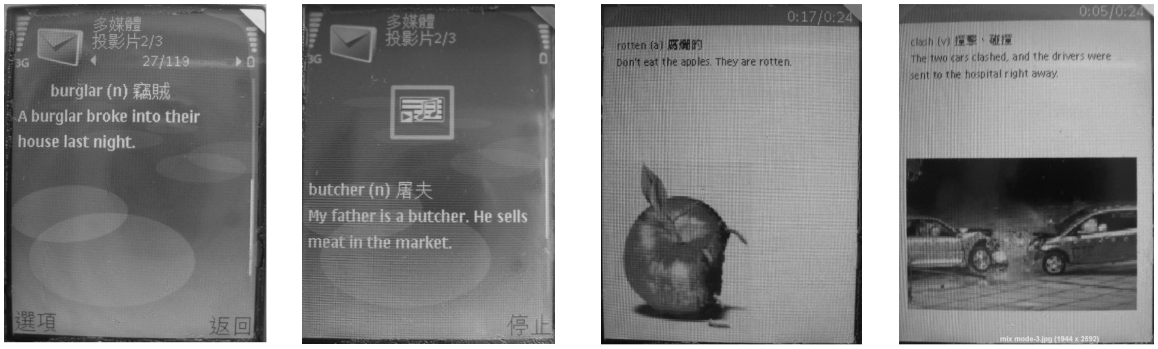

Figure 1. The four presentation modes of MMS vocabulary learning messages: (from left to right) text mode, audio mode, picture mode, and combined mode.

3.3 Procedures

In this within-subject study, all participants studied nine target words presented in one multimedia mode in one week. That required four different weeks to finish studying 36 target words. In each week, the nine target words were further divided into three groups. Each group contained one noun, one verb, and one adjective, which were composed of one MMS vocabulary lesson. In other words, it needed three MMS vocabulary lessons to finish delivering all nine target words. Because the English teacher demanded that each vocabulary item be learned twice, each MMS lesson was delivered to our participants twice every week. From Monday to Wednesday, the English teacher sent an MMS vocabulary lesson at 7 a.m. and 5 p.m., respectively. On Thursdays and Fridays, MMS lessons of jokes or short stories were delivered. The procedures of the study are shown below in Table 1.

Table 1. The procedures of the experiment

Week	Mode	Mon	Tue	Wed	Thu	Fri
1	Text	MMS 1a MMS 2a	MMS 3a MMS 1b	MMS 2b MMS 3b	2 lessons IM & CLQ	2 lessons
2	Audio & Picture	MMS 1a MMS 2a	MMS 3a MMS 1b	MMS 2b MMS 3b	2 lessons IM & CLQ	2 lessons
3		2 lessons	2 lessons	2 lessons	2 lessons Test	2 lessons DE on Text
4		2 lessons	2 lessons	2 lessons	2 lessons Test	2 lessons DE on Audio & Picture
5	Picture	MMS 1a MMS 2a	MMS 3a MMS 1b	MMS 2b MMS 3b	2 lessons IM & CLQ	2 lessons
6	Audio	MMS 1a MMS 2a	MMS 3a MMS 1b	MMS 2b MMS 3b	2 lessons IM & CLQ	2 lessons
7						DE on Picture
8						DE on Audio

Note. Words in 1a and 1b were identical and the order was different, so were those in 2a and 2b and those in 3a and 3b. IM=immediate post-test; CLQ=cognitive load questionnaire; DE=delayed post-test.

3.4. Instruments and data analysis

The instruments included an English vocabulary test on the target words and a cognitive load measurement (Paas & van Merriënboer, 1994), and a feedback questionnaire. One week before the experiment, all participants took the vocabulary test to check whether they had known any of the target words (pre-test). Then, the vocabulary test was administered after the vocabulary lesson of each mode (the immediate post-test) and two weeks after the lesson (the delayed post-test). The highest score for each set was 18 and the lowest 0. To measure their cognitive load, the participants were required to identify their mental load and mental effort on a seven-point rating scale, in which "1" referred to "very, very easy/low" and "7" meant "very, very hard/high." The highest possible score was 14 and the lowest 2. One-way ANOVA was employed to analyze the results of the pre-test and the cognitive load survey and two-way ANOVA to analyze those of the two post-tests.

4. Results

The results of the pre-test (M=0.00) showed no significant differences, suggesting an equivalence of knowing the four sets of target words. The descriptive statistics of the two vocabulary post-tests were presented in Table 2. The picture mode received the lowest scores of the four in both the immediate post-test (M=10.97, SD=4.020) and the delayed pot-test (M=9.16, SD=3.768). In the immediate post-test, our participants scored the highest on the target words presented in the audio mode (M=12.03, SD= 4.374); and in the delayed post-test, they seemed to favor the combined mode and scored the highest (M=10.41, SD= 3.723).

Table 2. Descriptive statistics for the vocabulary posttests

		Immediate		Delayed	
Mode	N	M	SD	M	SD
Text	32	11.19	3.922	9.22	3.625
Audio	32	12.03	4.374	9.63	3.415
Picture	32	10.97	4.020	9.16	3.768
Audio & Picture	32	11.88	4.172	10.41	3.723

Note. Maximum score = 18.

The two-way ANOVA revealed no significant differences among the four modes ($F(3,248)=1.106$, n.s.). It manifested significant differences between the two post-tests ($F(1,248)=15.510$, $p<.05$), in which the students scored higher in the immediate post-test (M=11.52, SD=0.344) than in the delayed post-test (M=9.60, SD=0.344). There were no significant interaction effects between the two independent variables ($F(3,248)=.160$, n.s.).

As far as the cognitive load on learners is concerned (Table 3), the text mode imposed the highest load (M=8.88, SD=1.540) while the combined mode the lowest (M=7.56, SD=1.813).

Table 3. Descriptive Statistics of the Cognitive Load Measurement

Mode	N	Mean	SD
Text	32	8.88	1.540
Audio	32	7.91	1.634
Picture	32	8.31	1.942
Audio & Picture	32	7.56	1.813

The results of the one-way ANOVA showed significant differences among the four modes ($F(3,93)=3.372$, $p<.05$). Pair-wise comparisons revealed the significant differences were between the text mode and the audio mode, the text mode and the combined mode, and the picture mode and the combined mode. Audio references seemed to help reduce our participants' cognitive load of learning new words.

5. Discussion

No significant differences of the four presentation modes were found in vocabulary gains and retention. Our adolescent learners showed no favoritism among words single-coded, dual-coded or triple-coded with multimedia information. That is, words with multimedia annotations delivered by MMS messages yielded similar learning results, as found in some previous research (Acha, 2009; Yanguas, 2009). Media-wise, the basic textual explanations of the target words found in all four modes, including Chinese equivalents and sample sentences, have already provided enough information for our participants. As Lin elaborated (2009), adolescent beginners do not need picture or audio references to learn words conveying common, daily-life concepts. A definition in L1 together with a sample sentence may have already created an essential context for our adolescent learners to learn the meanings of new words. Additional information, such as pictorial illustrations and pronunciations of words and sentences, may not be necessary for such vocabulary, which could explain why the picture mode received the lowest scores in both post-tests in the present study. The other clue for interpreting the similar results in learning vocabulary among the four modes could come from our participants' repeated exposures to the target words. The English teacher noted it was a common case that our participants would read a new MMS vocabulary lesson first and then review a previous lesson or two. Because of the screenful content of vocabulary lessons on cell phones, the participants could learn and review the lessons in a very short period. Occasions of their learning on the move included when they were waiting for a traffic light and when they were commuting. Our adolescent learners took advantages of the features of portability and immediacy found on mobile devices to help them learn. This naturalistic way of learning vocabulary found its support from many previous studies on mobile-assisted language learning (Levy & Kennedy, 2005; Lu, 2008; Stockwell, 2010). It certainly adds another piece of evidence for mobile-assisted vocabulary learning.

Significant differences in the cognitive load were found among the four presentation modes. More importantly, audio references played a crucial role in reducing our teenagers' cognitive load of learning vocabulary with multimedia annotations on cell phones. Of all the previous studies on multimedia annotations, only one study (Yeh & Wang, 2003) tackled the issue of sounds in vocabulary learning. The incorporation of the audio references was found inefficient due to the exceeding speed of reading, which their college students could not follow. The adolescent beginners of English in the present study, however, found that the audio references helped them reduce their cognitive load of

learning English vocabulary with or without pictures, when compared with learning with basic textual explanations alone. They also perceived differences between the two modes with pictorial illustrations. To beginners, the pronunciation or phonetics of vocabulary is inseparable with the form or orthography (Nation, 2001). Learning new words without a demonstration of how they are pronounced in isolation and in context gives L2 beginners too much burden. Other than its position in vocabulary learning for beginners, audio references also find its support from multimedia learning. As Mayer and Moreno (2003) explain, instructional designs adopting the modality principle and the temporal contiguity principle help learners increase working memory and reduce cognitive load. Written forms of new vocabulary items in the present study must be regarded as learning targets, different from the redundant subtitles of audio clips in their studies and their models (Mayer & Moreno, 2003). Audio references for beginners of English, providing an additional channel through ears, enhance our learners' understanding of the phonetic structures represented by the written forms. This additional channel of audio input designed in both audio mode and combined mode helped our beginners of English perceive differences in their cognitive load on learning vocabulary.

6. Conclusion

The present study investigated the effectiveness of learning English vocabulary with multimedia annotations on cell phones. The similar results could be attributed to the semantic simplicity of the target words and repeated exposures to the target words. The study also examined the degrees of cognitive load imposed by various multimedia. The comparatively lower cognitive load in audio references could be derived from their letter-sound associations and their enhancement input from an additional channel. This discrepancy attributed by the audio references highlights various directions for future research. First and foremost, evidences for how audio references assist vocabulary learning and acquisition in multimedia environments are in need. Pedagogically, language practitioners long knew that phonetic structures were crucial for vocabulary learning and acquisition (Nation, 2001). Studies on multimedia annotations, however, haven't been able to support that with empirical data. This study could not provide any evidence, primarily because both modes incorporated with audio references received higher scores in different post-tests but they failed to reach any significance level. A design with more considerations, including word types, age groups, proficiency levels, and cognitive styles, is needed. Next, studies on incidental vocabulary learning on the move should be carried out to determine the role of audio references in mobile-assisted vocabulary learning. The participants in the present study were asked to study a word list delivered to their cell phones. There was no accompanied reading text in which the target words were embedded. A more naturalistic way to acquire vocabulary in the mobile age is to read texts with multimedia annotations. Whether or not audio references play a similar role in reading on the move as in paper or web-based reading is worth studying.

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