Dictionary Types and Word Meaning Acquisition: Exploring Cognitive Load and Cognitive Processes

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Abstract: The aim of this study was to explore the effect of computer-mediated dictionaries on word meaning acquisition. Through analyzing the reading processes recorded by eye-tracking and the self-reported degree of cognitive load, we investigated learners' cognitive processes in meaning finding, and how they spent their mental effort on the dictionary content. The results showed that the readers using click-on and key-in dictionaries had no significant difference in the performances of word meaning test, in the fixation duration, and in mental effort spent on the dictionary content. However, readers using key-in dictonary had significantly higher average numbers of transitions between reading text and dictionary content than the ones who used click-on dictionary.

Keywords: Computer-Mediated Dictionaries, Vocabulary Acquisition, Cognitive Load, Cognitive Process, Eye Movement

1. Introduction

In second language vocabulary learning, many studies investigated how massive exposure to written languages could be an effective and efficient means (Hill & Laufer, 2003). The results of studies showed that learners often "picked up" words unintentionally while their goal was to comprehend the meaning of the text (Hulstijn, Hollander, & Greidanus, 1996; Kim, 2003). An effective solution to help learners understand the meaning of the words in order to comprehend the texts is to look up words in the computer-mediated dictionaries. The task of looking words up in the dictionaries requires readers to put their mental effort on cognitive processes. Does using different input types of computer-mediated dictionaries contribute to the same vocabulary learning, have the same cognitive processes, or require the same mental effort on finding the correct word meanings in the reading text?

1.1 Computer-mediated Dictionaries and Word Meaning Acquisition

Computer-mediated dictionaries have changed the way we look up words with traditional paper dictionaries and pocket electronic dictionaries. With computer-mediated dictionaries, we can find headwords (unfamiliar words) much more quickly, and also lessen the frequency of transitions between the dictionary content and the reading article. In this study, we used the two most commonly used dictionaries—the click-on dictionary and the key-in dictionary. Readers who use a click-on dictionary only have to do one click on the unfamiliar word with the mouse to get the word meanings. On the other hand, readers who use a key-in dictionary need to key in the spelling of the word in order to find its definitions.

Using dictionaries while reading helps learners learn vocabulary more effectively (Hulstijn, et al., 1996; Knight, 1994). Kim (2003) found that computer-mediated dictionary was more beneficial to learners' vocabulary learning compared to paper dictionary. In a study of investigating the influences of different types of dictionary on word meaning learning, Liu and Lin (2011) found that readers using three dictionary types (book dictionary, pop-up dictionary, and type-in dictionary) all performed better than readers without using any dictionary. However, there was no significant score difference among the three dictionary types.

1.2 Cognitive Load and Cognitive Processes

Sweller, van Merriënboer and Paas (1998) described the term *cognitive load* as the load imposed on the working memory while performing a particular task. Since people have limited working memory capacity, the real cognitive resource in working memory people spend on one task may influence the left cognitive resource to be spent on other tasks. While using a dictionary, learners undergo the cognitive process of looking words up: they notice unfamiliar words first, and then decide whether to look them up. Before finding the correct word meanings, readers have already spent their mental effort on finding headwords. From the perspective of cognitive load, we are interested in exploring how much cognitive load readers spend on finding the correct word meanings when they use click-on or key-in dictionaries.

Although many studies used log files to investigate the effect of dictionary consulting on vocabulary acquisition (Laufer & Hill, 2000; Liu & Lin, 2011), there are various cognitive factors that need to be considered in the process of using dictionary in reading. Tono (2011) stated that despite the growing numbers of studies on dictionary use, very few studies focused on investigating the actual dictionary look-up processes. In this study, we used eye-tracking technology to explore readers' actual dictionary look-up processes.

1.3 Eye-Tracking

Eye-tracking is now widely used to uncover learners' underlying cognitive processes in reading (Rayner, 2009). Researchers use eye-tracking technology to record where the readers actually look and fixate, so as to investigate the process of reading. In this study, we used this technology to collect data of the *fixation duration on dictionary content* and the *frequency of transitions between the dictionary content and the reading article*.

1.4 Purpose of the Study and Hypotheses

To further explore whether performances on word meaning learning differ when using different types of computer-mediated dictionaries, the present study used eye-tracking technology to record readers' fixation duration on dictionary content and transitions between the dictionary content and the reading article as they searched for the correct word meanings. From the perspective of cognitive load, we explored the effect of the different types of dictionaries on word meaning learning with self-reported mental effort when they spent on looking for the correct meaning and on reading the dictionary content.

Due to the different input types of the dictionaries, the time and cognitive load required to find the headwords are not the same. After readers find the headword, the time and cognitive load they further put in finding the correct meaning of the word from the dictionary content would be different. Therefore, we first postulated that test results of finding correct word meaning in click-on and key-in group should be different (H1). Under the condition that working memory was not overloaded, we postulated two

situations (H2 and H3) might exist. For Hypothesis 2, we postulated that the click-on group would use less cognitive load when they only needed to click on the unfamiliar word to get the headword in the dictionary. Therefore, learners needed to spend more cognitive load on the dictionary content and looking for the correct meaning (H2). On the other hand, we postulated that if learners consumed more cognitive load on finding headwords, they would spend more time and mental effort on reading dictionary content and looking for the correct word meaning (H3).

2. Method

2.1 Participants

The participants who volunteered to take part in the study were 18 Taiwanese undergraduates enrolled at National Central University. All participants learned English as a foreign language. They were between ages of 19 and 22 (M=19.919 years, SD=1.418 years; 9 females and 9 males). Participants were randomly assigned to the click-on dictionary group or the key-in dictionary group. This result of t-test indicated that there was no difference in their English proficiency before participated in this study, t (16) = 0.889, p = .387, d = 0.419.

2.2 Design

This study was a between-subject design with two treatments (using click-on dictionary and key-in dictionary). Reading and dictionary materials and computerized environment were controlled in both conditions. The content of dictionary was from Oxford Advance Learner's English-Chinese Dictionary (7^{th} edition). All words in the reading text could be found in both conditions. A planned contrast in analysis of variance (ANOVA) and Cohen's (1988) effect size index d were used to detect any significant differences between groups for all measurements. The level of confidence was set at the .05 significant level.

2.3 Vocabulary Matching Test

A word meaning matching test was designed to test 15 unfamiliar words (target words) with their correct meanings in the reading text. Additionally, to prevent the participants from simply guessing or being perfunctory, two definition options were added. The inter-reliability (KR20) of the vocabulary test was .713.

2.4 Cognitive Load Rating Scale

Two cognitive load rating questions were designed with a 9-point Likert scale (Paas, 1992). The participants were asked to rate numbers according to the mental effort they put in looking up the dictionary and reading the dictionary content. The larger the number, the more mental effort they threw in. The two questions were presented in Mandarin Chinese:

- How much effort do you think you spent on reading the information in the dictionary?
- How much effort do you think you spent on finding the correct word meaning for the article from the information in the dictionary?

2.5 Variables

To record participants' eye movement data, an EyeLink 1000/2k Eye Tracker at the sampling rate of 250Hz and a GazeTracker 9.0 eye movement data record and analysis software were used. The fixation duration was selected at 200 ms minimal. Five dependent variables were included:

- *The average word meaning learning performance* was represented by the total word meaning matching test scores divided by the number of participants.
- *The average fixation duration on dictionary content* was represented by the total fixation duration divided by the total number of checked items. Here, "the total fixation duration" referred to the sum of the fixation duration of each participant when they were reading the dictionary content of each target words. And "checked item" referred to the consulted words that were also assessed on the vocabulary matching test.
- *The average number of transitions between the dictionary and the article* was represented by the total number of transitions between the dictionary and the article divided by the total number of checked items. Here, "a transition between the dictionary and article" referred to the participant's delivery of their attention from the dictionary content to the article, and back to the dictionary content when they underwent the process of looking up definitions of the vocabulary.
- *The average cognitive load of reading dictionary content* was represented by the average self-reported number of mental effort spent on reading the information in the dictionary.
- *The average cognitive load of finding correct word meaning in the context* was represented by the average self-reported number of mental effort spent on finding the correct word meaning for the article from the information in the dictionary.

2.6 Procedure

The experimental sequence of the study took approximately an hour. The treatment consisted of two phases; they were tested individually on different dates. On the first phase, participants were screened for eye-tracking calibration and took the pretest. Next, each participant was randomly assigned to one dictionary group, and a practice version of experiment was provided to make sure that the participants got familiar with the functions of the computer-medicated dictionary. They were told to read for comprehension. Screen contents, mouse click actions, and eye movement were recorded. After the participants read the article with dictionary, they needed to finish the rating scale of cognitive load and the vocabulary matching test. Lastly, the participants were debriefed and thanked for their participation.

3. Results

In this section, variables related to this study (including vocabulary acquisition, cognitive processes and cognitive load) were analyzed and compared across the two different types of dictionary groups. The results were summarized in Table 1.

3.1 Word Meaning Learning Performance

A planned contrast in analysis of variance (ANOVA) was conducted to evaluate the scores of vocabulary matching test. For readers using different input modes of dictionary, there

was no significant test score difference, t (16) = -0.383, p = .352, d = 0.175, so Hypothesis 1 was confirmed. Participants in the click-on dictonary group had lower average scores of word meanig test (M = 9.222, SD = 2.635) than key-in dictionary group (M = 9.667, SD = 2.449).

3.2 Cognitive Processes

As for the time readers spent on reading dictionary content, a planned contrast in analysis of variance (ANOVA) of average fixation duration on dictionary content revealed no significant difference between two groups, t (16) = .779, p = .222, d = 0.300. However, the results revealed an important difference of the average numbers of transitions between the dictionary and the article across groups, t (16) = -2.426, p = .012, d = 0.933. Readers using key-in dictonary had significantly higher average numbers of transitions (M = 0.358, SD = 0.247) than the ones who used click-on dictionary (M = 0.622, SD = 0.315) .

Table 1. Results of variables in click-on and key-in dictionary groups

Variables	Click-on		Key-in				Cohen's
	M	*SD*	*M*	*SD*	*t*(16)	*p*	*d*
Vocabulary matching test	9.222	2.635	9.667	2.449	-0.383	.352	0.175
Average fixation duration on dictionary content	2.962	2.009	2.472	1.140	0.779	.222	0.300
Average number of transitions between the dictionary and the article	0.358	0.247	0.622	0.315	-2.426	.012*	0.933
Average cognitive load of reading dictionary content	3.889	1.691	4.889	2.315	-1.281	.106	0.493
Average cognitive load of finding correct word meaning in the context	4.222	1.563	6.000	2.398	-2.282	.016*	0.878

*p < .05

3.3 Cognitive Load

The mental effort which readers spent on the content in the dictionary showed no statistically significant differences, t (16) = -1.281, p = .106, d = 0.493. Further, the differences in the effort which readers spent on finding the correct word meanings in the article showed statistically significant differences, t (16) = -2.282, p = .016, d = 0.878. For readers using key-in dictonary, they significantly spent more effort on finding the correct word meanings for the article (M = 4.222, SD = 1.563) than the ones who used click-on dictionary (M = 6.000, SD = 2.398) .

4. Conclusion and Discussion

To conclude, this study was preliminary focused on comparing the differences between two types of computer-mediated dictionary groups in the processes of meaning finding in dictionary content. Although word meaning test scores were not significantly different (**H1 was not confirmed**), the cognitive processes and cognitive load readers spent revealed interesting results: H2 was not confirmed while H3 was confirmed. To compare with click-on group, readers in the key-in group invested more time and cognitive resources in the process of headword finding. In addition, they invested significantly more

activities of transition between dictionary content and reading article, and they spent more mental effort in finding the correct meaning of the word for the article.

What was the reason for key-in group to take more actions to differentiate the correct meaning of words in the article, but the performance of word meaning matching test did not get benefit from these actions? Liu and Lin (2011) found that there was no significant positive correlation between vocabulary searching time and vocabulary learning performance due to learners' constant attention-switching between the dictionary and the article. As was shown in Liu and Lin's (2011) research, the average vocabulary searching time of the two groups indicated that learners who used the key-in dictionary spent more time on searching the vocabulary. Furthermore, subjects of the key-in group needed to switch their attention between the dictionary and the article in order to type in the spelling. Thus the context that learners previously stored in working memory was interrupted, which led to more mental effort exerted on finding the correct meaning by referring back to the context.

When the process of storing the context in working memory was interrupted during keying in the spelling, the transitions between the dictionary and the article were only supposed to make up for the understanding of the article and not to further deal with the word meaning. In view of this, the key-in dictionary group put in more time and mental effort on vocabulary meaning finding compared with the click-on group, but no significant difference was found in the performance of vocabulary meaning test between the two groups.

Moreover, the present study indicated that, by analyzing learners' eye movements and cognitive load questionnaires, the average fixation duration on dictionary content and the self-reported number of mental effort of the two groups was not statistically significant. According to the average fixation duration on dictionary content (click-on: 2.962 seconds; key-in: 2.472 seconds), the key-in group spent a little less time on reading the dictionary content than the click-on group. It suggested that the key-in group did not put in as much time on the dictionary content as they significantly spent more effort on finding the correct word meanings during word meaning finding.

The results of the present study implied that the frequent transitions between the dictionary and the article of the key-in group might be to make up for learners' understanding of the context; therefore, they referred back to the text now and then to confirm word meanings. On the other hand, learners of the click-on group could get the word meaning as soon as they perform one click on unfamiliar words, and they could immediately verify the meaning by comparing the dictionary content to the context stored in working memory. As a result, the word meaning matching test scores of the click-on group were not significantly lower than those of the key-in group, despite there were fewer numbers of transitions between the dictionary and the article.

The limitation of the present study was the small sample size. The major contribution of this study was using the eye-tracking technology to directly obtain the time that readers spent on the dictionary content and the actions when readers switched their attention to find the correct meaning of the word in the article. We also obtained information of the readers' cognitive load which they reported individually. Combining these data, this study revealed more details on the processes of finding correct word meaning.

Although we did not find any significant difference in the performance of the word matching test between the two groups, through the information given by the participants' eye movement and their self-report data, we could further know the different cognitive process and cognitive load in the different types of dictionaries in word meaning acquisition.

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