Research Reports

Understanding Cognitive Load Using On-line Dictionaries

Robert F. Dilenschneider

General Education Department, English, Jichi Medical University, Yakushiji 3311-1, Shimotsuke, Tochigi, 329-0498 Japan

Abstract

Cognitive Load Theory may useful for language instructors to understand how the look up conditions of using an on-line dictionary might influence learning. This paper first reviews previous studies that have investigated dictionary use for vocabulary acquisition and reading comprehension Second, it explains the various elements of Cognitive Load Theory. Third, it describes how Cognitive Load Theory applies to language learners' to learn unknown words and comprehend texts Last, it discusses the pedagogical implications of using the cumulative cognitive load score to predict the amount of learning that might take place when learners use an on-line dictionary.

（Key words : Cognitive Load, Dictionary）

Studies Involving Dictionaries

In order to understand how Cognitive Load Theory might apply to the conditions of using on-line dictionaries, it is useful to look at previous studies that have examined dictionary use with regard to the learning of word forms, word meanings and passage comprehension. First with regard to learning word forms, Koyama and Takeuchi （2003） conducted a study that examined the spelling retention of target words looked up in a printed dictionary compared to words looked up in an electronic dictionary during a reading task. Their results, revealed that scores between the two groups were not significantly different in either recall tests in which learners had to reproduce the spelling of the target word, or in recognition tests in which learners had to identify the correct spelling of a target word.

Second, with regard to learning unknown words, several studies have been conducted with regard to how learners acquire the meanings of new words through the use of dictionaries. For example, some early studies involving book-based dictionaries have demonstrated that learners were better able to remember word meanings if they looked them up in a dictionary for a reading task （Cho & Krashen, 1994; Luppescu & Day, 1993）. Also, Hulstijn, Hollander, and Greidanus （1996） found that participants were more likely to remember the meanings of words if they looked them up in a dictionary versus learning them from a marginal glosses or from context. With regard to comparing the use of computer-based dictionaries, Knight （1994） found

participants who partially typed words into a computer learned more words than participants who relied only on the context of a passage. However, both Laufer and Hill （2000） and Peters （2007） found that mouse-clicking on words using an on-line dictionary did not correlate highly with recalling their meanings. Nevertheless, there are also some studies that compare the retention of word meanings using different types of dictionaries under different conditions. For instance, Liu and Lin （2011） found that students who used a pop-up dictionary learned words more quickly compared to those who used a type-in dictionary, and participants who used a type-in dictionary learned significantly more words than those who used a book dictionary. In addition, Amirian and Zahra （2013） found learners who used an electronic CD-ROM dictionary outperformed learners who used paper-based dictionaries.

Third, with regard to reading comprehension, previous studies involving the use of different types of dictionaries have presented mixed findings under several conditions and formats. Both Knight （1994） and Goyette （1997） found reading comprehension for learners was significantly better for learners who used a dictionary compared to those who did not use a dictionary. Also, although not significant, both Al-Sheir and Gitsaki （2010） and Prichard *et al.* （2011） found that learners who used a dictionary achieved higher comprehension scores compared to learners who did not use a dictionary. With regard to comparing the use of dictionaries during reading comprehension tasks, previous

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studies from Aust, Kelly and Roby (1993), Goyette (1997) and Liu and Lin (2011) did not find significant differences between learners who used computer-based on-line dictionaries and learners who used traditional book-based dictionaries. However, there are some studies that suggest that there is a difference in accessing word definitions while reading a passage with a computer dictionary. Both Chun (2001) and Al-Sheri and Gitsaki (2010), for instance, found that comprehension is greater when learners read a passage and simultaneously view word definitions from a gloss or from an on-line dictionary compared to when learners transfer away from a passage to access word definitions in an external on-line dictionary.

Cognitive Load Theory

The finding from previous studies that have explored the use of dictionaries are varied. These mixed results may be attributed to the design of each study and the amount of mental effort or cognitive load they placed on participants. Cognitive Load Theory (CLT) (Sweller, 1988) is a concept, "to provide guidelines intended to assist in the presentation of information in a manner that encourages learner activities that optimize intellectual performance." (Sweller *et al,* 1998). Specifically, this theory hypothesizes that three types of cognitive load determine how information is learned. First, intrinsic cognitive load refers to the idea that all instruction has an inherent difficulty associated with it. For example, the calculation of multiplying 2 x 2 has an inherent difficulty. Although the calculation can be broken down into subschemas or smaller calculations and then synthesized, it has inherent properties that cannot be altered by an instructor. Next, extraneous cognitive load refers to how information is presented to learners. It can be altered to eliminate unnecessary information in order to make learning easier. For instance, the procedure to calculate 2 x 2 can be shown either visually or described verbally to learners. Using figures written on a chalkboard, the visual representation of 2 x 2 can be quickly understood; however, a verbal description of multiplying 2 x 2 might take learners more time and effort to conceptualize. In this respect, the verbal information is extraneous and overloads learners' ability to process information; as a result, it limits their capacity for learning. Last, germane cognitive load refers to the mental effort learners devote to learning new material. This cognitive load can also be altered by instructors, if, for example, instructional presentations with abstractions and elaborations are created to help learners process and learn information.

In order for efficient learning to occur, CLT states that learners' cognitive capacity should not be overloaded. Both intrinsic and extraneous cognitive loads are cumulative and can limit cognitive resources in working memory for learning (Sweller *et al.,* 1998). Therefore, instructors should

reduce the extraneous cognitive load of tasks and redirect instructional attention to the germane cognitive load to promote more effective learning.

Researchers have explored how intrinsic cognitive load, extraneous cognitive load, and germane cognitive load impact vocabulary learning and text comprehension tasks in both paper-based and computer-based studies. In a paper-based study Yeung, Jin, and Sweller (1997), compared the effects on vocabulary learning and passage comprehension when high and low proficiency ESL readers read vocabulary definitions integrated in a reading passage (integrated format) to when they read with list of vocabulary definitions separate from a reading passage (separated format). In this study, the cognitive load activity breaks down as follows: the intrinsic cognitive load was learning new words and comprehending the information in the reading passage, the extraneous cognitive load was the presentation of vocabulary definitions that were either integrated or separated from the reading passage, and the germane cognitive load was the mental effort learners devoted to learning and comprehending the material in the text.

The integrated format with definitions inserted enhanced passage comprehension but reduced vocabulary learning for the low proficiency ESL readers. At the same time, the integrated format reduced passage comprehension but enhanced vocabulary learning for high proficiency ESL learners. The researchers explained that previous knowledge of words that were defined in the reading passages might have compromised comprehension. That is, because word meanings were already known by the high proficiency learners, the presence of vocabulary definitions in the integrated format reading passages were more difficult to ignore compared to vocabulary meanings that were in the separate format reading passages. As a result, the integrated definitions were a redundant source of information and thus interfered with comprehension, as they imposed an extraneous cognitive load on high proficiency learners, overloading their ability to process information.

In a computer-based study, Al-Sherhri and Gitaski (2010), examined the effects of comprehension and vocabulary learning with participants who read texts and separately answered comprehension questions in a split-attention format versus those who read texts with comprehension questions inserted within a text in an integrated format. In this study, the intrinsic cognitive load was learning new words and comprehending the information in the reading passage, the extraneous load was the presentation of comprehension questions that were either inserted in or separated from the text, and the germane cognitive load was the mental effort learners devoted to answering those questions. Twenty intermediate ESL students were randomly assigned to four conditions of Split-Attention

No Dictionary (SAOD), Split-Attention with pop-up On-line Dictionary (IFOD), Integrated Format No Dictionary (IFND), and Integrated Format with a pop-up On-line Dictionary (IFOD).

Mean scores revealed that access to an on-line dictionary was better for vocabulary learning and the Integrated format promoted better reading comprehension. The researchers explain that the extraneous cognitive load of using an on-line dictionary was greater for participants who read passages in the Split-Attention format compared to participants who read passages in the Integrated format. With regard to comprehension, the participants who read passages in the IFND and IFOD formats consistently completed the reading comprehension test faster than the participants who read passages in the SAND and SAOD formats. With regard to vocabulary learning, the participants using the Split-Attention on-line dictionary format (SAOD) looked up about 30% more words than the Integrated on-line dictionary format (IFOD). The Split-Attention format reduced the effectiveness of the on-line dictionary because the participants in the SAOD condition needed to look up more words compared to those in the IFOD condition. As a result, the Split-Attention format of switching attention back and forth between web pages to complete reading comprehension and vocabulary tasks was too extraneous in that it caused a cognitive overload in terms of processing information.

On-line Dictionary Use and Cognitive Load

Cognitive Load Theory can be used to build upon previous studies involving dictionaries of how language learners might use an on-line dictionary while reading authentic texts by means of the three conditions of Control, Click and Spell. For example, learners who use a book-based dictionary or an on-line dictionary can learn the meaning of unknown words in a reading passage from the Control condition, that is, from guessing the meaning of an unknown word from its surrounding context. However, compared to a traditional book-based dictionary in which learners only look up the definition of an unknown word, there are essentially two different conditions afforded to language learners when they access an on-line dictionary linked to an on-line dictionary. For example, the Click condition allows learners to read a text on their computer and click on a word which transfers them away from the reading passage to the definition of that word in an on-line dictionary. The Spell condition also allows learners to read a text on their computer. However, in order to transfer to the on-line dictionary, the learner must first click on the unknown target word. Once transferred to the on-line dictionary, the learner must then type the spelling of that word in the on-line dictionary to access its definition.

In determining the effectiveness of each condition, a cumulative cognitive load score for the intrinsic (inherent difficultly of a task), extraneous (the presentation of information), and the germane (mental effort to process information) can be assigned for each condition. For example, with regard to the Control condition, there is the intrinsic load or inherent difficulty of understanding a reading passage, the extraneous load or presentation of information is on one page, and the germane load or mental effort to process and understand the meanings of unknown words and passage content can be learned from the reading passage itself. As a result, the cumulative load score for this condition is 3 (1 intrinsic + 1 extraneous + 1 germane = 3).

The cumulative cognitive load for the Click condition is more robust than the Control condition. For example, like the Control condition, there is the intrinsic load of understanding passage content. However, unlike the Control condition, the extraneous load of information is presented on two separate platforms, the reading passage and the on-line dictionary. In addition, the germane load to process and understand the meanings of unknown words and understand passage content involves a two-step process. First, a learner must read the passage. Second, a learner must recall the meanings of newly learned words for context of a reading passage. Therefore, the cumulative cognitive load score for this condition is 5 (1 intrinsic + 2 extraneous + 2 germane = 5).

The Spell condition has the largest cumulative cognitive load score of the three conditions. Like the Control and Click conditions, there is the intrinsic load of passage content. In addition, the extraneous load of information, like that of the Click condition, is presented on two separate platforms, the reading passage and on-line dictionary. However, unlike the Click condition, the germane load or mental effort to learn the unknown words of a text involves a three step process. First, a learner must read the passage. Second, a learner must take note of a word form in order to access it in an on-line dictionary. Third, a learner must recall the meanings of newly learned words for the context in a reading passage. Therefore, the cumulative cognitive load score for the Spell condition is 6 (1 intrinsic + 2 extraneous + 3 germane = 6). Table 1 reveals the intrinsic, extrinsic and germane loads in relation to the Control, Click and Spell conditions of using an on-line dictionary.

Table 1. *Intrinsic, Extrinsic and Germane Cognitive Loads in Relation to On-line Dictionary Conditions.*

Cognitive Load	Conditions		
	Control	Click	Spell
Intrinsic	1	1	1
Extrinsic	1	2	2
Germane	1	2	3
Total	3	5	6

Pedagogical Implications

The cumulative cognitive load score can help language instructors to predict and understand the amount of learning that learners might experience when they conduct language tasks that involve the use of an on-line dictionary. The Control condition, for example, allows learners to focus attention on only the reading passage and does not involve either the extra presentation of a word in two platforms or the mental effort to recall the form of a word to access its meaning outside the context of a reading passage. Therefore, this condition might be more conducive for passage comprehension, but least favorable for learning the forms and meanings of new words. Under this condition, instructors who want their learners to focus only on passage content might consider texts that do not overwhelm their learners with a great deal of unknown words.

The Click condition divides learner attention between two separate platforms and involves two steps to access and learn the meanings of words in an on-line dictionary. Because this condition involves two platforms and takes learner attention away from the reading passage, it might be less effective for passage comprehension and more effective for learning word meanings. As a result, instructors may consider using this condition for their learners to engage in tasks that focus on the meanings of new words more than the overall content of a passage.

The Spell condition divides learner attention between the two separate platforms of a reading passage and an on-line dictionary and involves three steps to note the form of a word, access an on-line dictionary, and type the form of a word in the on-line dictionary in order to access its meaning. Under the Spell condition, the extra presentation of the target word on the two platforms of the reading passage and an on-line dictionary along with the mental effort to recall the form of a word to access its meaning outside the context of a reading passage, place a high cognitive load on a learner. Although this condition might have some benefit to acquire the meanings of unknown words, it might be least effective for passage comprehension but the most effective for learning word forms. Thus, this condition might be best for exposing learners to the spellings of new words.

This paper attempted to demonstrate how Cognitive Load Theory can be helpful for language instructors to understand how the conditions of using an on-line dictionary might influence learning. As with other methods and resources in language learning, this is not to say that one condition will always be superior to the others. Issues such as learner proficiency level, word difficulty, passage content, length of text as well as other conditions to learn words while reading, either in combination or as a single factor, are all elements to consider that might potentially impact the amount of learning. This might be why the analysis of the cognitive load in this study coincides or contradicts with some of the findings of previous studies concerning dictionary use. Nonetheless, it is useful for language instructors to be mindful of how cognitive load might impact learning so that the tasks they design can potentially produce the best results.

REFERENCES

Al-Shehri, S., & Gitsaki, C. (2010). Online reading: A preliminary study of the impact of integrated and split-attention formats on L2 students' cognitive load. *Recall, 22,* 356-375.

Amirain, S. M. R., & Heshmatifar, Z. (2013). The impact of using electronic dictionary on vocabulary learning and retention of Iranian ELF learners. *International Journal of Research studies in Education Technology, 2,* 35-44.

Aust, R., Kelly, M., & Roby, W. (1993). The use of hyper-reference and conventional dictionaries. *Educational Technology Research and Development ,41,* 63-73.

Chun, D. (2001). L2 reading on the web: Strategies for accessing information in hypermedia. *Computer Assisted Language Learning, 14,* 367-403.

Cho, K., & Krashen, S. (1994). Acquisition of vocabulary from the Sweet Valley Kids series: Adult ESL acquisition. *Journal of Reading, 37,* 662-667.

Goyette, S. (1997). The effects of dictionary usage on text comprehension. *Humanities and Social Sciences, 57,* 42-64.

Knight, S. M. (1994). Dictionary use while reading: The effects on comprehension and vocabulary acquisition for students of different verbal abilities. *Modern Language Journal, 78,* 285-299.

Koyama, T., & Takeuchi, O. (2007). Does look-up frequency help reading comprehension of EFL learners? Two empirical studies of electronic dictionaries. *CALICO Journal, 25,* 110-125.

Laufer, B., & Hill, M. (2000). What lexical information do L2 learners select in a CALL dictionary and how does it affect word retention? *Language Learning and Technology, 3,* 58-76.

Liu, T., & Lin, P. (2011). What comes with technological convenience? Exploring the behaviors and performances of learning with computer-mediated dictionaries. *Computers in Human Behavior, 27,* 373-383.

Luppescu, S., & Day, R. R. (1993). Reading dictionaries and

vocabulary learning. *Language Learning, 43,* 263-287.

Peters, E.（2007）. Manipulating L2 learners' online dictionary use and its effect on L2 word retention. *Language Learning and Technology, 11,* 36-58.

Prichard, C., & Matsumoto, Y.（2011）. The effect of lexical coverage and dictionary use on L2 reading comprehension. *Reading Matrix: An International Online Journal, 1533242X, 11.*

Sweller, J.（1988）. Cognitive load during problem solving: Effects on learning. *Cognitive Science, 12,* 257-285.

Sweller, J., Van Merrienboer, J., Pass, F.（1998）. Cognitive architecture and instructional design. *Educational Psychology Review, 10,* 251-296.

Yeung, A.S., Jin, P., & Sweller, J.,（1997）. Cognitive load and learner expertise: Split attention and redundancy effects in reading with explanatory note. *Contemporary Educational Psychology, 23,* 1-21.

オンライン辞書を用いた認知負荷の理解

ロバート　デイレンシュナイダー

自治医科大学　総合教育部門　英語　栃木県下野市薬師寺3311-1

要　　約

　認知負荷理論は，言語タスクに関連する学習条件の有効性を予測するのに使用できる有用な概念です。たとえば，オンライン辞書は，未知語の意味を学習するために学習者に異なる条件を与える言語リソースです。したがって，本稿では，認知負荷理論がどのように語学講師がオンライン辞書を使用する条件が学習にどのように影響するかを理解するのに役立つことを示しています。まず，語彙獲得と読解のための辞書の使用を調査した以前の研究をレビューする。第二に，学習のための認知負荷理論の異なる要素が説明される。第3に，認知負荷理論に関連するオンライン辞書の使用は，未知の単語およびテキストの理解がどのように処理され得るかを理解するために記載される。最後に，学習者がオンライン辞書を使用するときに起こり得る学習の量を予測するために，累積認知負荷スコアに基づく教育学的含意が議論される。

（キーワード：Cognitive・Load・Dictionary）