Effect of visualization of relation among words in electronic English-Japanese dictionary

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Abstract: We proposed a visualized Japanese WordNet to improve narrow display in electronic dictionaries and to memorize new words. WordNet® is an English lexical database by Princeton University, literally presenting relation of words. We confirmed the learning effect of our proposal comparing to the current electronic dictionary, using 36 Japanese students. Results showed that there were no differences in ratios of correct answers between of the visualized WordNet and of the current dictionary, but that in the 1-week-after test the ratio was significantly higher in learning with our proposal. The result of a questionnaire revealed that learners who felt the ease to memorize words using the visualized WordNet tended to get higher scores in both tests. Interviews revealed its inexperience but a possibility for long-term learning. Despite of unfamiliarity, our proposal showed certain learning effect. The visualization of relation among words is a new displaying style to solve its narrowness.

Key words: visualization, word representation, human cognition, electronic dictionary, foreign language learning.

1. Introduction

In Japan, electronic dictionary has become a big seller. In 1997, electronic dictionary shipments were 300,000 units, but they increased to 2,805,000 units in 2007. Now its annual sales reached 46.3 billion [1]. On the other hand, although, in 1993, printed dictionary shipments were 1,500,000 units and its annual sales were 30 billion, its shipments were 650,000 units and its annual sales were 16.3 billion [2]. The electronic dictionaries spread out rapidly and the market of printed dictionaries shrinks. We see transition between the printed dictionary to the electronic dictionary in Japanese market.

However, schools and teachers do not welcome the electronic dictionary [3]. In Japan, English education starts from junior high school. Teachers complain about students, because they do not want to use the dictionary to study English. The students tend to look at only meanings of the target word in the printed dictionary and do not examine detailed description. Thus, the teachers worry that the students just look at the word and finish the

search, if they use the electronic dictionary. The teachers seem to distrust learning effect of the electronic dictionary.

Previous studies about the electronic dictionary were classified into 6 categories, taxonomy, utilization study, searching speed and frequency, retention of words, comprehension of text, and effective usage [4]. Abe (2007) pointed out merits of portable electronic dictionary as rapid searching, available while offline, portability and easy searching, and its demerits as unavailable data processing and hardness to find the target word because of hierarchical structure [5]. As for comparison between the electronic dictionary and the printed dictionary, we got a conclusion of significant time crunch of searching in usage of the electronic dictionary [6, 7, 8, 9]. About the retention of words, some researches declared the printed dictionary winner [10,11], but other suggested the advantage of the electronic dictionary [7]. Researchers were also split on comprehensibility of text using the electronic dictionary, but some of them pointed out the possibility of facilitation by the electronic dictionary [6, 7, 12]. Narrowness of display in the electronic dictionary was shown as a defect [13,14].

2. Purpose of study

Review of the previous studies presents us 2 major problems, uncertain effect to retain the words and narrow display surface. We proposed a new displaying system to solve these 2 problems. Main idea was visualization of relation among words in the display of electronic dictionary. In our hypothesis, its visualization was one of effective method to use the limited display area and to promote the learning of English. Purpose of the present study was examination of our proposal, to confirm the effect of visualization of relation among words to retain new words.

We cannot deny the digitalization in every field. It will be inadvisable to persistently avoid using the electronic dictionary by learners of foreign language. We would like to search for the common ground between the producer side and the user side, or between market and schools and teachers.

3. About the WordNet®

The narrowness of display surface of the electronic dictionary seems fatal and to have not a chance of winning against the printed dictionary. Enlargement of display is not a realistic solution. Then, we took a completely different approach to solve the problem.

We pay attention to WordNet® which is a lexical database of the English language developed by Cognitive Science Laboratory of Princeton University [15]. The WordNet® textually presents the relation of words. The official site explains its features as follows. Nouns, verbs, adjectives and adverbs are grouped into sets of cognitive synonyms (synsets), each expressing a distinct concept. Synsets are interlinked by means of conceptual-semantic and lexical relations. The resulting network of meaningfully related words and concepts can be navigated with the browser. Synsets are group of related words. So, if you input a word in the WordNet®, you will see antonym, hypernym, hyponym, meronym, holonym, entailment, derivationally related form, or verb group.

Representation of relation among words can encourage the retention of new words. In fact, WordNet® is developed and examined by cognitive scientists. According to Kintsch (1998), new knowledge would become stable, when it combined with existing knowledge of the learner [16]. Another models or concepts of cognitive psychology, semantic network, spreading activation and priming effect, can show validity of WordNet® for learning.

Let us consider a case that you, as a Japanese student, had to learn a word, "guzzle". If you used a printed dictionary, you would know Japanese meaning of "guzzle"; if you used a dictionary as thick as a telephone directory, you would see some usage examples. But, neighbors of "guzzle" have no relation of meaning to it. In the printed dictionary presents a large number of words alphabetically. On the other hand, WordNet® shows direct hypernym, inherited hypernym, sister term, derivationally related form and sentence frame of "guzzle". When you found a word already known, you could imagine the meaning of "guzzle" and combine it to the existing knowledge; when you saw "drink" in the direct hypernym, you could understand that "guzzle" is a form of drinking.

Semantic network [17] is a representation of knowledge model, which is organized by semantic relationship; if concepts are semantically close, their distance in the network is small. Concepts are represented by nodes and combined by arrows called as link. This network has hierarchical structure; "canary" does not directly combine with "eating food", but 3 relations, "canary as a subset of bird", "bird as a subset of animal" and "animal eats food", conducts "canary eats food". If a concept is stimulated, activation diffuses according to the link and related nodes are also activated. Degree of activation is proportional to the distance in the network. Reaction time of identification task of two words is shorter, if the words are located closer [18]. For instance, if you should say "yes" to a target word, "nurse", you can response to it more quickly after presenting "doctor" than after presenting "butter". This is semantic priming effect. Thus, in the network, once a node is activated, the effect spreads out according to the links. The WordNet® is the very semantic network and has possibility to promote word learning.

4. Proposal

Although we explained the effectiveness of using WordNet® for the electronic dictionary, original WordNet® is not so suitable to represent the relation among words in it. The WordNet® is a lexical database, so that all words are just listed. Then, we proposed a visualization of among words as a new display style in the electronic dictionary.

Figure 1 is an example of a display. The words visually represented in the proposal were hypernym, hyponym, antonym, synonym, derivative, and reference of the target word; these relations between the target word and represented words were shown as colored lines. Difference of word class was represented as difference of colors of background circle. Legend symbols representing these features were shown at the low part of the display.

Sequential representations in the usage are as follows. Firstly, user types a word in the searching tab and enters. If the word match the data of the WordNet®, the synsets of the target word appear. This is visualization of

relation among words. If the user mouseovers a word, its meaning in Japanese appears. If the users doubleclicks a word, its related words appear. The position of words is movable. Moreover, history of words searched can be also shown in the history mode.
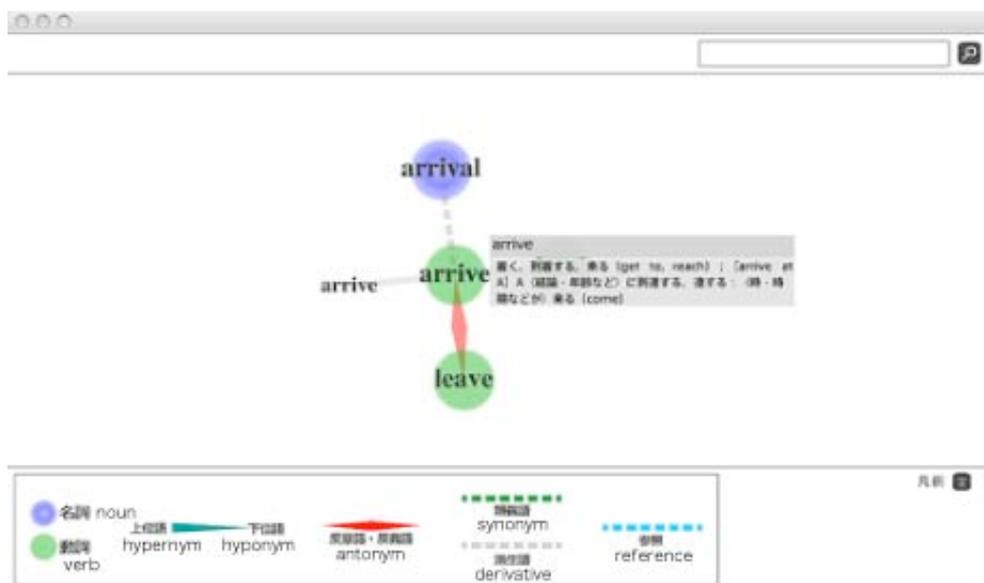

Figure 1. An example of display of our proposal

The proposal was constructed as a web application and could work in the web browser. Adobe Flash (SWF), PHP, and XML were used. The system was operative like following sequence. 1) User inputs of a word, 2) the SWF receives the word and sends a list of letters of the word to the PHP, 3) the PHP requests the word data to the WordNet® and receives the data, 4) the PHP transforms the data as XML data and sends them to the SWF, 5) the SWF reads the data and represents it in the web browser, and 6) the user sees the results of search.

Moreover, we translated the meanings and example sentences into Japanese. Thus, our proposal operates as an English-Japanese dictionary. For the translation, we used Genius English-Japanese dictionary 3rd edition [19], because a preliminary studies revealed that this was a dictionary most used by college students.

5. Examination of the proposal

5.1 Purpose and general outline of examination

The purpose was to confirm the effect of visualization of relation among words to retain the word. If the visualization was effective, it would be a good method as a new display in the electronic dictionary.

Firstly, participants learned several words using our proposal dictionary or a commercial electronic dictionary. Then, a test of vocabulary was done. After that, the participants completed a questionnaire and did interviews. After a week, they took the second vocabulary test. All of steps in the examination were done as an individual session.

5.2 Method

5.2.1 Participants

Thirty-six undergraduate and graduate school students participated in the examination (from 22 to 26 years-old, 25 males and 11 females). Their mother language was Japanese. They daily used the electronic dictionary.

5.2.2 Target words

All words that the participants had to learn were verbs and were not so frequently-appearing words. The Genius dictionary set 4 levels of importance and frequency. We selected the words from 3rd and 4th levels, that is, quasi-maximum and maximum level, because a preliminary experiment showed that 25 undergraduate and graduate students clearly did not know the words in these 2 levels in comparison to the words in other 2 levels. There were 14 target words divided into 2 groups; detect, grant, discredit, perish, redress, devastate, and miscarry were in list 1, and halt, anticipate, detest, confound, fetch, enchant, and guzzle were in list 2. Seven words in a list were printed in a sheet of paper.

5.2.3 Dictionaries

Two dictionaries were used; our proposal of the visualized WordNet and a commercially available electronic dictionary. The latter was a CASIO Ex-word XD-R1300 which contained the same dictionary as used for the translation in the visualized WordNet.

In the visualized WordNet, just 3 words appeared. These represented words contained at least one word that junior high school students or high school students should know. The legend symbols always appeared in the below of display. The visualized WordNet used a computer display, but the area displaying the words was the almost same size as the commercial electronic dictionary (480 pixels × 320 pixels).

5.2.4 Procedure

All of participants received an explanation on the use of visualized WordNet; how to input a word and how to understand the display. After that, they were instructed about the task.

Then, 36 participants were divided into 4 groups, to counterbalance of the effect of dictionaries and that of word lists. Members in group A and in group B used firstly the commercial electronic dictionary and lately the visualized WordNet. Members in group C and in group D used 2 dictionaries in an opposite order, firstly the visualized WordNet and lately the commercial electronic dictionary. Members in group A and in group C learned firstly the list 1 and lately the list 2. On the other hand, members in group B and in group D learned firstly the list 2 and lately the list 1. Learning time was 5 minutes for the commercial electronic dictionary and 6 minutes for the visualized WordNet. The difference in time was set from the preliminary experiment to measure the time for learning of 7 words. During learning period, the participants could freely make notes and start to study from any word.

After the learning period, they took a test; they had to translate 4 sentences contain the target words into Japanese and to write spelling of 2 target words. Thus, 6 of 7 learned word appeared in the test, in different order from that in the list.

When the participants experienced 2 times of learning period and of test with different dictionaries, they answered a questionnaire with 21 evaluation items (Table 1) using a 5-point scale to evaluate the visualized WordNet. The items were selected from a previous study [9].

After the questionnaire, the participant did interviews and he or she could freely give feedback about the use of each dictionary.

At the last, after a week of the learning period, the participant took the test. The same words as in the first test were presented in randomized order.

Table 1. Evaluation items in the questionnaire to evaluate the visualized WordNet (No. 8 and No. 15 were reversed items)

1	I did not get eyestrain.
2	I did not get tired of use it
3	I could easily operate it.
4	I could study the list at my own pace.
5	I could repeat the target word in my head.
6	I had more incentive.
7	It was fun.
8	It needs to use repeatedly.
9	I could remember the answer in short time.
10	The right answers popped up.
11	It was easy to remember the right answer.
12	I did not spend a long time to get the right answer.
13	I got the right answer smoothly.
14	I could write the right answer in one breath.
15	I spent a long time to get the right answer.
16	I could remember many answers.
17	It is suitable to learn English.
18	It was easy to use.
19	I found function to be satisfactory.
20	It is favorable to learn English.
21	It is generally superior.

5.3 Results

5.3.1 Rate of correct answers

Figure 2 represents averaged rates of correct answers. In the immediate test, the rates of both dictionaries were the almost same value, over 0.8. However, in the 1-week-after test, the rate of visualized WordNet was higher than that of the commercial electronic dictionary; the former was over 0.5, but the later was less than 0.5.

A 2-way ANOVA with repeated measure was done for factor of dictionary and that of test timing. A main effect of test timing and an interaction between 2 factors were significant ($F(1, 35)=152.15$, $p<.001$; $F(1, 35)=4.98$, $p<0.5$). Simple-main effects of test timing were significant both in the visualized WordNet ($F(1, 70)=74.84$,

$p<.001$) and in the commercial electronic dictionary ($F(1, 70)=127.26$, $p<.001$). And a simple-main effect of dictionary was significantly revealed in the 1-week-after test ($F(1, 70)=4.31$, $p<.05$).

Thus, immediately after the learning, the learning effect of the visualized WordNet was the same as the commercial electronic dictionary, but after a week there was a difference between them. The effect of the visualized WordNet persisted more than the commercial electronic dictionary.
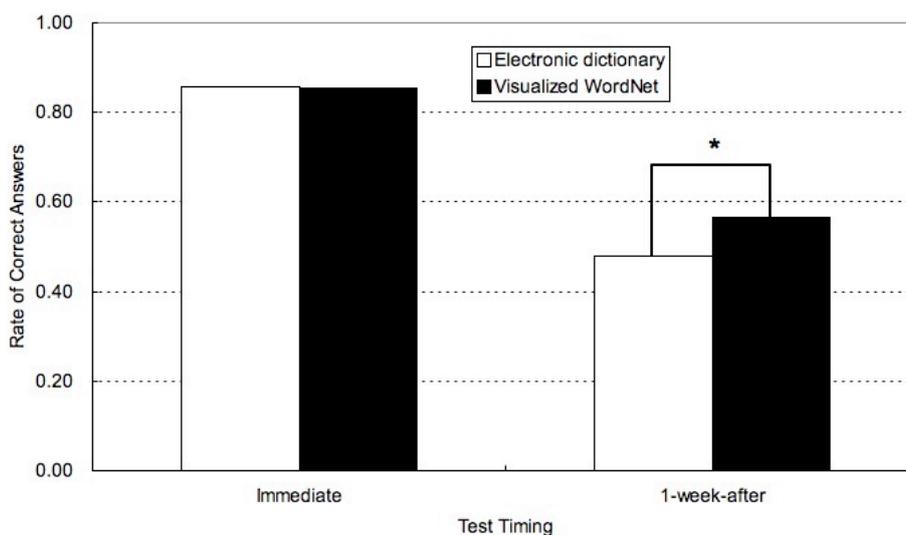

Figure 2 Averaged rates of correct answers as a function of the test timing for 2 dictionaries

5.3.2 Results of questionnaire

A factor analysis of principle factor method was conducted to the data of 21 questions by 36 participants. Using varimax rotation, 5 factors were got, whose cumulative percentage contribution was 68.31 %. The factors were named as "suitable for learning", "appeal", "time crunch", "user-friendliness", and "reduce of burden", respectively.

Separately, difference values between the correct ratio of the visualized WordNet and that of the commercial electronic dictionary in each participant were calculated. Coefficients of correlation between these difference values and each factor scores were worked out. For the immediate test, the coefficient of correlation was 0.41 ($t(35)=2.630$, $p<.05$), and for the 1-week-after test, the value was 0.55 ($t(35)=3.873$, $p<0.0005$). Thus, we could say that the learner who regarded the visualized WordNet as suitable for learning got higher score in each test. There was no correlation between other factor scores and difference values of dictionaries.

5.3.3 Results of interviews

Each participant freely debriefed about the use of two dictionaries in the learning period. Comments by more than 2 participants were as follows. As negative comments to the visualized WordNet, a) uneasy to memorize the target word because of the lack of example sentences and idiom, b) need to functions mounted in the current commercial electronic dictionary like search refinement, c) uneasy to understand the importance of word, and d) discontented with GUI,.

On the other hand, positive comments were summarized as follows; a) good to know the relation between the target word and the learned words, b) urging to search the learned word to know the relation to other words, and c) suitable for the learning of speaking, not for that of reading.

6. Discussion

The results of interviews and of questionnaires revealed that not all of participants were for the visualized WordNet. It was the first time for them to use our proposal, the visualized WordNet; they might have difficulty to get use to it. As some participants pointed out, it was lack of some important functions that the commercial electronic dictionaries usually mounted. Thus, the visualized WorNet had a disadvantage for the learning period and for the vocabulary test, comparing to the commercial electronic dictionary.

However, the score of the immediate test of the visualized WordNet was statistically the same as that of the commercial electronic dictionary. Instead, in the 1-week-after test, the former score was significantly higher than the later score. The visualized WordNet could make participants to retain the target words, regardless of its inexperience. The effect of learning exceeded the inconveniences from the inexperience.

Thus, we confirmed the effect of visualization of relation among words to retain the word. The positive comments mentioned above were considered as the possibility to use for long-term learning. Since the participants wanted to use the visualized WordNet to know related words to the word that they had already learned and known, the repetitive use of the visualized WordNet will increase the learning effect more.

6. Conclusion

To solve 2 main problems of the current commercial electronic dictionary, we proposed a new system using the WordNet®. The visualization of relation among words helped the retention of new words and considered as a new display to overcome its narrowness. If students can remember the new words using the electronic dictionary, teachers and schools will not complain about it.

We know that visualization of relation among words itself is not so innovative idea for the dictionary, because it is already realized as in Visual Thesaurus® [20]. However, our proposal was backed up by concrete psychological facts. The examination reported here revealed statistically usefulness of the visualized WordNet. Thus, our proposal is not just a unique or fashionable way of the representation for dictionary, but a scientific proposal to solve the problem. Moreover, not only the Visual Thesaurus® but also the WordNet® is an English-English dictionary, but our proposal is an English-Japanese dictionary. We confirmed the effect of the visualization of relation among words in foreign language learning.

Although we must improve the GUI and consider mounting many functions on the visualized WordNet, at this time, we proved its positive learning effect as a new displaying system of the electronic dictionary.

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