The Role of Processing-Resource Allocation in Incidental L2 Vocabulary Learning Through Reading

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Abstract

The present study investigates the role of vocabulary processing in incidental L2 vocabulary learning through reading within the framework of the type of processing-resource allocation (TOPRA) model (Barcroft, 2000). According to the TOPRA model, the allocation of L2 learners’ cognitive resources determines what aspect of L2 vocabulary (e.g., meaning, form, and form-meaning connection or FMC) is learned. The model also predicts that one type of processing depletes remaining resources that otherwise could be used to process other aspects of vocabulary; this is considered to be a necessary consequence, as learners’ cognitive resources are limited. Within this framework and using university-level Japanese EFL learners, the present research compares the effects of semantic processing and form processing with the lack of any particular vocabulary processing (control). The results show that, in general, semantic processing inhibits the learning of forms and FMCs of new L2 vocabulary, whereas form processing accelerates the learning of new L2 forms but inhibits the learning of FMCs. These results suggest that processing-resource allocation plays an important role in incidental new L2 vocabulary learning.

1. Introduction

Adult second language (L2) vocabulary acquisition differs from first language (L1) vocabulary acquisition in the respect that, in most cases, L2 learners have already acquired almost all semantic (conceptual) representations in their L1. Therefore, learners can make use of their L1 semantic information in order to understand the meaning of new L2 vocabulary (Coady, Magoto, Graney, & Mokhtari, 1993; Jiang, 2000). It is true that the semantic spaces of the L1 and L2 vocabularies are not exactly the same (Dong, Gui, & MacWhinney, 2005), yet it is also true that “much of the semantic information appropriate for a given word in the L1 and L2 may overlap and be transferred” (Barcroft, 2003, p. 547). Therefore, at the beginning stage of L2 vocabulary development, learners do not have to acquire new semantic representations. Rather, their primary goal at this stage of L2 vocabulary development is the acquisition of new L2 forms (Coady et al., 1993; Jiang, 2000). In L2 vocabulary acquisition research, L2 forms refer to lexemes (see VanPatten, Williams, & Rott, 2004). The knowledge of the L2 word form itself, however, does not
work in L2 use. Learners need to connect a new L2 form to its meaning. Recent research has been showing that, in order to establish this initial form-meaning connection (FMC), learners should complete, at the very least, the following three subprocesses: (a) encode the form of new L2 vocabulary in memory, (b) activate an appropriate semantic meaning for the form, and (c) map the form onto the meaning (Barcroft, 2003). The final component is equivalent to FMC, and this is assumed to be the most essential knowledge in L2 vocabulary acquisition (Schmitt, 2008). Then, one fundamental question is how different types of vocabulary processing affect the learning of new L2 forms and the establishment of initial FMCs. The present study investigates this issue by utilizing the type of processing-resource allocation (TOPRA) model (Barcroft, 2000), which has dealt directly with this issue, to explore the role of vocabulary processing type on the learning of new L2 vocabulary through reading.

2. Type of Processing-Resource Allocation Model

In order to show the relationship between different types of cognitive processing and new L2 vocabulary learning, Barcroft (2000) suggests the type of processing-resource allocation (TOPRA) model. This model is visualized as follows:

![Figure 1](image)

Figure 1. Relationships between processing type and learning in the TOPRA model (Barcroft, 2003, p. 549)

The basic idea of this model is that “different amounts of specific types of processing predict similar corresponding amounts of the same types of learning” (Barcroft, 2003, p. 548). The two thick outer lines in the model do not move. They represent the limit on the overall processing capacity of a learner. On the other hand, the inside lines in the model move according to the types of processing in which the learner engages. Their corresponding learning outcomes increase or decrease according to the movement of the inside lines. For example, when a learner uses larger amounts of resources for semantic processing, semantic learning increases. However, form processing and mapping processing (and corresponding form learning and mapping learning)
decrease as a necessary consequence, since a learner’s overall processing resources are limited.

This prediction was confirmed by Barcroft (2009) in incidental L2 vocabulary learning research. He compared a semantic processing group in which participants generated synonyms of each target word in their L1 with a control group in which participants did not have any particular vocabulary processing tasks (control). L1-to-L2 (L1-L2) and L2-to-L1 (L2-L1) vocabulary translation tests were used to assess learners’ vocabulary gain. It was expected that knowledge of both L2 forms and FMCs are necessary for the two tests, but the relative importance of the two types of knowledge is different for each test (Barcroft, 2009). That is, knowledge of L2 forms is more important for the L1-L2 test since the production of L2 forms is required. On the other hand, for the L2-L1 test, learners are asked “only to generate L1 counterparts, rendering performance on this task less dependent on L2 word form than the L1-to-L2 recall task for which no L2 word forms were provided” (Barcroft, 2009, p. 99), and therefore knowledge of FMCs is more important for the L2-L1 test. Then, according to the TOPRA model, increased semantic processing inhibits the learning of forms and FMCs of new L2 vocabulary. Therefore, the performance of the semantic processing group should be lower than that of the control group in the two vocabulary post-tests. Results were consistent with these predictions and implied inhibitory effects of increased semantic processing in learning new L2 vocabulary.

Even though the results obtained by Barcroft (2009) were straightforward, some concerns remain. First, it is necessary to replicate his experiment by using a different type of semantic processing task. By doing so, it becomes possible to further advance our understanding of the role of semantic processing in new L2 vocabulary learning. Second, it is necessary to explore the role of form processing in L2 vocabulary learning. Barcroft (2009) simply compared the semantic processing group with the control group, and he did not set up a form processing group. According to the TOPRA model, L2 word form processing facilitates L2 word form learning simultaneously, thereby decreasing the possibility to learn new FMCs. Therefore, form processing should be more beneficial than control in learning new L2 forms, while form processing should have a negative impact on learning new FMCs. This prediction of the TOPRA model should be empirically tested.

3. Hypotheses

In order to investigate the role of semantic and form processing in incidental L2 vocabulary learning and further test the validity of the TOPRA model, the present study compares semantic and form processing of new L2 vocabulary with no particular vocabulary processing (control). On the basis of the predictions of the TOPRA model, this study tests the following hypotheses:

1. Semantic processing inhibits the learning of both vocabulary forms and FMCs of new L2 vocabulary.
2. Form processing facilitates the learning of new L2 vocabulary forms and inhibits the learning of FMCs of new L2 vocabulary.
4. Method

4.1 Participants

The participants in the present study were 137 female Japanese learners of English at a university. They were from two intact classes, which were assumed to have similar English proficiencies. Participants from one class were assigned into the L1-L2 vocabulary translation group, while participants from the other class were assigned into the L2-L1 vocabulary translation group (see the Design section below). Data of six participants were eliminated from the analyses, because they did not complete all of the experimental procedures. All the participants were native speakers of Japanese, and their English proficiency was assumed to be intermediate. The background information of the participants is shown in Table 1.

Table 1

<table>
<thead>
<tr>
<th>Participants' Background Information on English Language Experience (N = 131)</th>
<th>N</th>
<th>Min</th>
<th>Max</th>
<th>M</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Beginning age of English learning</td>
<td>131</td>
<td>5</td>
<td>14</td>
<td>11.19</td>
<td>1.58</td>
</tr>
<tr>
<td>TOEIC scores</td>
<td>101</td>
<td>240</td>
<td>575</td>
<td>399.01</td>
<td>75.68</td>
</tr>
<tr>
<td>Self-assessed ratings:</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Speaking</td>
<td>131</td>
<td>1</td>
<td>7</td>
<td>2.92</td>
<td>1.58</td>
</tr>
<tr>
<td>Listening</td>
<td>131</td>
<td>1</td>
<td>7</td>
<td>3.31</td>
<td>1.32</td>
</tr>
<tr>
<td>Reading</td>
<td>131</td>
<td>1</td>
<td>8</td>
<td>3.84</td>
<td>1.43</td>
</tr>
<tr>
<td>Writing</td>
<td>131</td>
<td>1</td>
<td>8</td>
<td>3.84</td>
<td>1.43</td>
</tr>
</tbody>
</table>

Note: Self-assessed ratings indicate how participants are proficient in each skill (0: minimum proficiency to 10: near-native proficiency)

4.2 Materials

Three materials were used in the experiment: the reading text, booklet of comprehension questions, and two vocabulary post-tests.

The reading text used in the experiment consisted of 797 English words, including 10 target words. The text was developed by the researcher himself. All the words in the text, except the 10 target words, were under the 3000 word level in the JACET 8000 basic word list (JACET, 2003). The 10 target words were over the 8000 word level. The target words were: abattoir, carcass, entrails, feces, pellet, shack, tusk, vermin, venison, and veterinarian. The L1 translations of each target word were shown as marginal glosses at the bottom of the reading text. The text was an introduction to research showing the human-health dangers of using lead-based ammunition when hunting deer. This topic was chosen because it was assumed that the participants were not familiar with it; hence, their topic familiarity would be similar among experimental conditions. The readability (Flesch-Kincaid) of the text was 10.3.

In the booklet of comprehension questions, 10 multiple-choice questions were printed. Each
question asked the meaning of a sentence or phrase in the text that contained one target word. The options of the multiple-choice questions consisted of a correct answer and two distractors. The two distractors were based on the following two criteria: (a) the sentence is correctly parsed but the meaning of the target word is incorrect and (b) the meaning of the target word is correct but the parsing of the sentence is incorrect. All multiple-choice options were written in Japanese.

Vocabulary processing tasks were embedded in the comprehension question booklet. Two different types of vocabulary processing tasks were used in the present study: semantic and form processing. The participants in the semantic processing group engaged in the pleasantness rating task, in which the participants made pleasantness ratings about the meaning of each target word (0: very unpleasant to 14: very pleasant). This task has been used in early psychological studies (e.g., Hide & Jenkins, 1969) and TOPRA model-based studies (Barcroft, 2002) in order to make participants process the semantic aspect of target stimuli. The participants in the form processing group performed the phonological encoding task in which they wrote down the pronunciation of each target word in Japanese Katakana. When phonological encoding takes place in English, learners' cognitive processing is "the direct analysis of phonological elements embedded in the graphemic representation" (Koda, 1989), and this does not mediate semantic processing of the target word. Therefore, the task was assumed to require the participants to process the form of the target vocabulary. Each vocabulary processing task appeared after each comprehension question in both semantic and form processing groups. The participants in the control group did not have any vocabulary processing tasks and only answered the same 10 multiple-choice comprehension questions.

Two vocabulary post-tests used in the present study were L1-L2 and L2-L1 vocabulary translation tests. The two tests were used because (a) the target of L2 vocabulary acquisition is to acquire L2 forms and FMCs and (b) L2 learning objectives almost always include the knowledge of L2 vocabulary in two directions: L2 form to meaning and meaning to L2 form (Hulstijn, 2001). By using both L1-L2 and L2-L1 vocabulary translation tests, we can meet these two criteria.

4.3 Scoring

Two different scoring methods were used for both L1-L2 and L2-L1 tests: stringent and lenient scoring. With stringent scoring of the L1-L2 test, a correct answer was scored as 1 and any other responses were scored as 0. With lenient scoring, a correct answer was also scored as 1. However, in this scoring method, learners' partial knowledge of L2 form was scored based on the proportion of correctly produced letters. For example, if a learner responds *caere or *carcess for the word carcass, 0.29 and 0.86 points are given, respectively, since the beginning two letters (2/7 letters) and six letters (6/7 letters) are correct, respectively. Responses that did not include any correct letters or were blank were scored as 0. Since learners' knowledge of L2 vocabulary exists on a continuum from partial to precise (Henriksen, 1999), this type of lenient scoring is necessary when learners' partial knowledge of L2 vocabulary is assessed (Barcroft, 2002).
Both stringent and lenient scoring methods were also adopted in scoring the L2-L1 test. With stringent scoring, the correct answer was scored as 1 and any other responses were scored as 0. With lenient scoring, the correct answer was scored as 1, and the responses semantically related to the correct meaning were scored as 0.5 (e.g., 散弾銃 for the word pellet). The responses that were not semantically related or were left blank were scored as 0.

Since the present study used real L2 words, there was a possibility that the participants knew some of the target words before the experiment. Therefore, the two translation tests asked them if they had had prior knowledge for each target word. If they indicated “yes,” no points were given for the response, even if it was correct.

4.4 Design

The present experiment dealt with vocabulary processing type (semantic, form, control) as a between-subject variable. In order to avoid the so-called testing effect, vocabulary test direction (L1-L2, L2-L1) was also administered in a between-subject design. Therefore, six conditions (3 × 2) were created in total. Since the participants were from two intact classes, the participants from one class were assigned to the L1-L2 vocabulary translation group, while the participants from the other class were assigned to the L2-L1 vocabulary translation group. In both cases, the participants were randomly assigned to the three (semantic, form, and control) conditions.

In the present experiment, no delayed post-test was administered, because the focus of the present study was to examine the role of cognitive processing during the first encounter with new L2 vocabulary; the retention of said vocabulary was not the focus of this study. In this case, an immediate post-test was sufficient to assess the role of cognitive processing (Hulstijn, 2003).

4.5 Procedure

The experimental tasks were administered in participants’ normal class hours. The participants first received the reading text and the booklet of comprehension questions. They were informed that they had 20 minutes to complete the comprehension questions. Twenty minutes later, the participants were instructed to turn over both the reading text and the comprehension questions. Since the present study used the incidental learning paradigm (see Hulstijn, 2001, for the detailed discussion and operational definition of this paradigm), the participants were not informed in advance that they would have a vocabulary post-test; rather, they were unexpectedly given one of the vocabulary post-tests. During the test, they were not allowed to see either the reading text or the comprehension questions. The post-test ran for five minutes.

5. Results

The descriptive statistics for the L1-L2 and L2-L1 vocabulary translation tests of all three groups (semantic, form, and control) appear in Table 2.
Table 2

The Mean Scores and Standard Deviations of Each Group in the L1-L2 and L2-L1 Tests with Stringent and Lenient Scoring (Max = 10)

<table>
<thead>
<tr>
<th></th>
<th>L1-L2 Test</th>
<th>L2-L1 Test</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>n</td>
<td>Stringent</td>
</tr>
<tr>
<td></td>
<td></td>
<td>M  SD</td>
</tr>
<tr>
<td>Semantic</td>
<td>19</td>
<td>0.68 0.82</td>
</tr>
<tr>
<td>Form</td>
<td>23</td>
<td>1.30 1.22</td>
</tr>
<tr>
<td>Control</td>
<td>23</td>
<td>0.61 0.72</td>
</tr>
</tbody>
</table>

With the stringent scoring of the L1-L2 test, the mean score of the form processing group was the best, followed by the semantic processing group, and the control group was the worst. However, the mean scores of the semantic processing and the control group showed the floor effect. With the lenient scoring of the L1-L2 test, this problem might be avoided. Again, the mean score of the form processing group was the best. However, the performance of the control group was better than that of the semantic processing group in this scoring method. With the stringent scoring of the L2-L1 test, the mean score of the control group was the best, followed by the form processing group, and the semantic processing group was the worst. With the lenient scoring of the L2-L1 test, the form processing group got the highest mean score, followed by the control group, but the difference was small in this case. The semantic processing group was the worst.

Four one-way ANOVAs were administered for each result (stringent scoring of the L1-L2, lenient scoring of the L1-L2, stringent scoring of the L2-L1, lenient scoring of the L2-L1). The ANOVA for the stringent scoring of the L1-L2 test revealed that there was a significant difference between the mean scores of the three groups, $F(2, 62) = 3.60, p = .03, \eta^2 = .01$. The post-hoc analysis by Ryan’s method revealed that the difference between the semantic processing and control group was not significant, $t(40) = 0.26, p = .80$, nominal level = .03, $r = .03$, while the form processing group and control group was significant, $t(44) = 2.47, p = .0161$, nominal level = .0167, $r = .30$. The difference between the semantic and form processing groups was reaching significance, $t(40) = 2.10, p = .04$, nominal level = .03, $r = .26$. The other three ANOVAs did not reveal any significant differences between the three groups: for lenient scoring of the L1-L2, $F(2, 62) = 1.66, p = .20, \eta^2 = .00$; for stringent scoring of the L2-L1, $F(2, 63) = 0.25, p = .78, \eta^2 = .00$; for lenient scoring of the L2-L1, $F(2, 63) = 0.38, p = .69, \eta^2 = .00$.

6. Discussion

The present study was carried out with the following two hypotheses: (1) semantic processing inhibits the learning of both vocabulary forms and FMCs of new L2 vocabulary and (2) form processing facilitates the learning of new L2 vocabulary forms and inhibits the learning
of FMCs of new L2 vocabulary. The results generally supported the two hypotheses. As with Barcroft (2009), the results of the present experiment showed the tendency of semantic processing to inhibit the learning of forms and FMCs of new L2 vocabulary. Even though the differences between the semantic processing group and control group were not statistically significant in either the L1-L2 or the L2-L1 tests, the mean scores of the semantic group in the two tests were always lower than those of the control group except with the stringent scoring of the L1-L2 test. However, the floor effect appeared in that case; therefore, it is difficult to assume that the semantic processing positively affects the learning of new forms tested by the L1-L2 translation.

As for the second hypothesis, the results showed that form processing promoted the learning of new L2 forms and inhibited the learning of initial FMCs. The mean score of the form group was significantly higher than that of the control group with the stringent scoring of the L1-L2 test. With the lenient scoring, the difference did not reach the statistical significance, but still, the performance of the form processing group was better than that of the control group. In the L2-L1 test, however, the mean score of the control group was higher than that of the form processing group with the stringent scoring of the L2-L1 test. With the lenient scoring, the form processing group was slightly better than the control. As argued above, the knowledge of both L2 forms and FMCs are necessary in order to correctly answer the L2-L1 translation test, but the knowledge of FMCs is more important for this test since the learners are not required to produce L2 forms; rather, they are asked only to recognize the L2 forms in question and generate their L1 counterparts. According to the TOPRA model, form processing facilitates learning of new L2 forms, but the increased form processing inhibits the learning of initial FMCs. Therefore, the performance of the form processing group in the L2-L1 test should be lower than that of the control group. In the present experiment, even though the difference between the form processing group and the control group did not show a statistically significant difference, the result of the stringent scoring of the L2-L1 test was consistent with this prediction of the TOPRA model.

In sum, the results of the present study showed that, in general, increased semantic processing inhibits or has null effects on the learning of new L2 forms and FMCs, while increased form processing promotes the learning of new L2 forms but inhibits the learning of FMCs. These results can be understood as a general support of the TOPRA model.

The results of the present study somewhat conflict with our intuition and some of previous studies that posited the positive effect of semantic processing on human memory (e.g., Craik & Lockhart, 1972). The participants of the semantic processing group in this study had much more time and allocated more of their cognitive resources to deal with target words than did those in the control group. The participants in the control group simply answered the 10 multiple-choice questions and did not have any vocabulary processing task. Hence, it is assumed that the time and cognitive resources they used to process the target words were less than those of the semantic processing group. The participants in the semantic processing group could use some of their time and cognitive resources only to process the target word. Nonetheless, the performance of the
semantic processing group was worse than that of the control group in both the L1-L2 and L2-L1 vocabulary translation tests. This confirms the findings of some previous TOPRA model-based studies (Barcroft, 2000, 2002) and implies the potential inhibitory effect of semantic processing in learning new L2 vocabulary.

7. Conclusion

The present study shows that vocabulary processing types affect the learning of new L2 vocabulary. Particularly, this study suggests that increased semantic processing inhibits the learning of forms and FMCs of new L2 vocabulary, whereas form processing promotes the learning of new L2 forms and inhibits the learning of FMCs of new L2 vocabulary. These results are generally consistent with the prediction of the TOPRA model and suggest that L2 learners’ cognitive processing-resource allocation plays an important role in new L2 vocabulary learning.

In respect to pedagogical implications, this study suggests that both teachers and learners should be aware of the inhibitory effects of increased semantic processing for new L2 vocabulary learning. This is because if teachers do increase semantic processing, learners cannot learn new L2 forms and FMCs of the vocabulary, which is the essential L2 vocabulary knowledge. On the other hand, it may be worthwhile for L2 learners to allocate their cognitive resource to L2 word forms in order to learn new L2 forms. Yet, it may be possible that increased form processing inhibits the learning of FMCs of new L2 vocabulary. However, in later stages of L2 vocabulary development (e.g., to learn L2-specific meanings of a word or new meanings of a polysemous word), semantic processing may be beneficial (Barcroft, 2009), while form processing may not be beneficial, since the learners already acquire the L2 forms in these stages. Therefore, both teachers and learners should be aware of the role of learners’ cognitive processing-resource allocation and should carefully consider to what vocabulary aspect L2 learners should allocate their processing resources at each stage vocabulary development.

Acknowledgement

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References


