Which is the Better Predictor of Reading Comprehension,  
Lexical Route¹ or Non-Lexical Route²?

Ikuko KOSHIMIZU  
Yamanashi Prefectural Shirane High School

Abstract

Pronounceable words are divided into two types; one is known words and the other is unknown words or pseudowords. According to L1 research, many theorists have found that phonological decoding based on word pronunciation has correlation with reading comprehension skills, whether the words are known or pseudowords. In Japan, one L2 study dealt with known words and showed that there is a relationship between the efficiency of phonological decoding and reading comprehension. However, there is hardly any study concerned with pseudowords. Because Japanese people tend to recognize a word as a whole form, not as assembled letter-strings based on letters-to-sound translation rules, their lexical route efficiency might be activated, but it can not be presumed that their non-lexical route efficiency is the same. The following study was initiated in order to clarify how Japanese learners’ reliance on lexical route in learning words would relate with reading comprehension. This study showed that there is a more significant relationship between the efficiency of phonological decoding and reading comprehension with pseudowords than there is with known words. This result suggests that word learning be done with the tactic of segmenting words with the knowledge of letters-to-sound translation, rather than with holistic memorization that Japanese learners of English are more likely to use.

1. Introduction

Phonological decoding is getting from a written word its lexical information and holding it in the phonological short-term store for further processing, such as lexical access and semantic parsing, by converting the written information into a sound-based representational system (Baddeley, 2000). Some L1 researchers assert that phonological decoding based on word pronunciation correlates with reading comprehension skills (Bell & Perfetti, 1994; Gathercole and Baddeley, 1993). According to the dual-route model (Coltheart, 1978), there are two independent routes to pronouncing words. One of the routes is called “lexical route,” which deals with known words. The other is called “non-lexical route,” which deals with unknown words or pseudowords. Perfetti and Hogaboam (1975) showed that skilled L1 readers are activated in non-lexical route efficiency as well as lexical route. Some theorists even suggest that non-lexical route efficiency
can most clearly differentiate good from poor readers (Hogaboam & Perfetti).

Among the limited number of experiments on Japanese subjects, one study by Miyasako and Takatsuka (2004) concluded that the articulation speed of English words correlates with reading comprehension. However, their experiment dealt only with known words and failed to test subjects’ pronunciation of pseudowords. Through comparison of lexical route with non-lexical route, the following study makes clear the relation between Japanese learners’ efficiency of phonological decoding and reading comprehension skill and explores the possibility of making use of phonological decoding in improving reading comprehension skill.

The research questions of this study are as follows:
RQ1: Does the phonological decoding via lexical route have correlation with reading comprehension?
RQ2: Does the phonological decoding via non-lexical route have correlation with reading comprehension?
RQ3: Which efficiency of phonological decoding predicts reading comprehension skill better, lexical route or non-lexical route?

2. Method

2.1 Subjects

This study took place in 2008 at a public academic high school. The subjects were 40: 22 boys and 18 girls. All of them were first-year students whose English proficiency was at average or below in comparison to other first-year Japanese high school students. In a school week, the subjects took three General English classes and two Oral Communication classes, one being based on English grammar, the other being conversational English taught through team teaching by a Japanese teacher and an American teacher.

2.2 Material

(1) Efficiencies of phonological decoding through lexical route

The subjects’ articulation speeds and accuracy of 20 known words (Appendix A) were examined to measure the efficiency of phonological decoding through the lexical route. The known words used in this experiment were chosen so that more than 90% of the participants had the semantic information of these words in their mental lexicon and even the lowest level subject scored more than 85% at the preliminary test (Appendix B). 20 words were printed on half of an A4-sized paper (10.5×15.0cm) with an 18.0 font size. The known words were all chosen from a Japanese authorized textbook of English for junior high school.

The formula for the efficiencies of lexical route was as follows:

- Efficiency of lexical route = The number of the known words pronounced accurately / time for articulating 20 known words
(2) Efficiencies of phonological decoding through non-lexical route

As a unit of phonological decoding, body\(^3\) was used instead of the grapheme-to-phoneme conversion rule. This was chosen because many L1 researchers have found that body is superior for measuring phonological decoding efficiency (Taft, 1991) and that children's phonological awareness of rime predicts their improving reading ability (Bowey & Underwood, 1996; Bryant, MacLean, & Bradley, 1990).

20 pseudowords (Appendix C) were constructed to measure the subjects’ efficiency of phonological decoding through non-lexical route. They were one-syllable words that consisted of onset and rime. In order to make a clear assessment, body parts in this study came from the consistent words which had only one pronunciation, as seen in the experiment of Glushko (1979). However, the onsets of Glushko’s original words were changed for fear that the participants should access similar entries in their mental lexicon and retrieve the pronunciation information from them.

The formula for the efficiencies of non-lexical route was as follows:

- Efficiency of non-lexical route
  
  \[
  \text{Efficiency} = \frac{\text{The number of the pseudowords pronounced accurately}}{\text{time for articulating 20 pseudowords}}
  \]

(3) English proficiency

English proficiency was measured based on the total score (100 points) of an older version of Basic Assessment of Communicative English (BACE) made by the Association for English Language Proficiency Assessment (ELPA). For this study, the total score of the test was believed to be an appropriate measure of English proficiency.

This test was chosen for the following three reasons: first, it consists of three parts: listening comprehension, vocabulary and grammar, and reading comprehension. Second, the test level was made in accordance with a course of study in English education for Japanese junior high school and was therefore deemed appropriate for the subjects. Third was the impartiality of this test because it uses a multiple-choice answer system.

(4) Reading comprehension

Reading comprehension was measured by the scores in the reading section (40 points) of an older version of BACE. This test was determined to be appropriate because the vocabulary and grammar were of junior high school level and the content of passages would not be too difficult to understand. This was important because if the vocabulary or contents were too difficult, the subjects would be likely to rely more on upper-level processes, like semantic processing, rather than on the lower-level processes, such as phonological decoding ability, and it could lead to the floor effect.
(5) Word learning skill

By using a computer, word learning skill was measured to find out whether phonological decoding was activated by the subjects in the process of learning a word. After two pseudowords were shown as a stimulus (Appendix D), subjects were required to memorize both of them as accurately and as fast as possible to choose the same pair of pseudowords out of four similar options on the next screen. Subjects had the responsibility to change the screen for next question but were not allowed to see the previous screen. The pseudowords used in this test were all the same as what were used in test (2), "efficiencies of phonological decoding through non-lexical route."

The formula for the word learning skill was as follows:

- Word learning skill = Time for memorizing and choosing the answers / the number of the correct answers

(6) Vocabulary size

Vocabulary size was measured by the Mochizuki Vocabulary Size Test (Mochizuki, 1998). There were two reasons why this test was deemed appropriate. First, the test offered seven levels—1,000- to 7,000-word levels—which made it possible to choose the very beginner’s level for this study. Second, the answer style was to choose an answer out of six multiple choices, a format which Japanese students were accustomed to. The chosen questions were 60; 30 from the 1,000-word level, and another 30 from the 2,000-word level.

2.3 Procedures

Lexical route efficiency and non-lexical route efficiency were tested individually after school in a quiet classroom. For this first assessment, the speed and accuracy of reading known words and secondly, pseudowords, were measured respectively. Known words were tested first with the intention that the subjects would feel relaxed with these tests. In order to measure the time as accurately as possible, the first word utterance was treated as just the starting sign and was not assessed. An IC recorder recorded all of the performances of subjects from a location they couldn’t see.

For the next assessment, the BACE test was given to the subjects for forty-five minutes during a regular class. The total score (40 points) of the three parts—listening comprehension, vocabulary and grammar, and reading comprehension—was regarded as a representation of students’ English proficiency. English proficiency was assessed by the reading comprehension score of the BACE.

The word learning test was carried out at a different occasion after school in a quiet classroom. This test was carried out two months after the subjects’ non-lexical route efficiency was measured for fear they would remember those words.

The vocabulary size test was carried out during class. Each question offered 6 multiple
English word choices for every 2 Japanese meanings; subjects were expected to choose the appropriate English word to correspond to the Japanese. The number of questions was 60; there were 30 from the 1,000-word level, and 30 from the 2,000-word level. The total score of the vocabulary size test was 60 points.

3. Results

Table 1. Means and SD’s for lexical route efficiency, non-lexical route efficiency, English proficiency, reading comprehension, word learning skill and vocabulary size

<table>
<thead>
<tr>
<th></th>
<th>Mean</th>
<th>SD</th>
<th>Min.</th>
<th>Max.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Lexical route efficiency</td>
<td>1.34</td>
<td>.40</td>
<td>.61</td>
<td>2.86</td>
</tr>
<tr>
<td>2 Non-lexical route efficiency</td>
<td>.20</td>
<td>.17</td>
<td>.03</td>
<td>.80</td>
</tr>
<tr>
<td>3 English proficiency</td>
<td>18.90</td>
<td>3.65</td>
<td>11.00</td>
<td>29.00</td>
</tr>
<tr>
<td>4 Reading comprehension</td>
<td>4.98</td>
<td>1.73</td>
<td>1.00</td>
<td>8.00</td>
</tr>
<tr>
<td>5 Word learning skill</td>
<td>14.02</td>
<td>7.52</td>
<td>6.80</td>
<td>52.00</td>
</tr>
<tr>
<td>6 Vocabulary size</td>
<td>41.10</td>
<td>4.53</td>
<td>29.00</td>
<td>49.00</td>
</tr>
</tbody>
</table>

n = 40

Table 2. Correlation matrix for lexical route efficiency, non-lexical route efficiency, English proficiency, reading comprehension, word learning skill and vocabulary size

<table>
<thead>
<tr>
<th></th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Lexical route efficiency</td>
<td>.56**</td>
<td>.41*</td>
<td>.35*</td>
<td>-.08</td>
<td>.21</td>
<td></td>
</tr>
<tr>
<td>2 Non-lexical route efficiency</td>
<td>.42**</td>
<td>.44**</td>
<td>-.25</td>
<td>.43**</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3 English proficiency</td>
<td>.73**</td>
<td>-.19</td>
<td>.49**</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4 Reading comprehension</td>
<td>-.13</td>
<td>.42**</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5 Word learning skill</td>
<td></td>
<td>-.59**</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* p<.05  ** p<.01

Note English proficiency is derived from the total points of BACE. Reading comprehension is derived from the reading comprehension part points of BACE.

Table 1 shows the means and SD’s of lexical route efficiency, non-lexical route efficiency, English proficiency, reading comprehension, word learning skill and vocabulary size. Table 2 shows the correlations between them. According to these tables, 1) non-lexical route efficiency has a higher correlation with English proficiency and reading comprehension than lexical route efficiency, 2) non-lexical route efficiency has a correlation with vocabulary size while lexical
route efficiency does not, 3) lexical route efficiency and non-lexical route efficiency have significant correlation, 4) both English proficiency and reading comprehension have significant correlation with vocabulary size, 5) word learning skill has a significant correlation with vocabulary size, but no correlation with lexical route efficiency, non-lexical efficiency, English proficiency or vocabulary size.

4. Discussion

4.1 Research question (1)
The phonological decoding efficiency through lexical route (pronunciation of known words) showed a slight correlation with reading comprehension. However, on the other hand, the lexical route efficiency showed no relationship to the vocabulary size. This might be the reason that the efficiency of lexical route doesn’t have a significant correlation to reading comprehension skill. Because Japanese learners tend to recognize a word as a whole form (Brown & Haynes, 1985), they might learn words like the way children recognize “McDonald’s” when they see the “M” sign. It implies the difficulty for many Japanese learners to increase vocabulary effectively, which make it difficult for them to be better readers of English text.

4.2 Research question (2)
Phonological decoding efficiency through non-lexical route (pseudoword pronunciations) was found to have a significant correlation with reading comprehension. There appears to be two reasons for this:

- The first reason is based on the viewpoint of increasing vocabulary. In learning a new word, letter-to-sound correspondences enable learners to repeat unknown words in a phonological loop, which makes the learning easier. Several researchers found that repetition ability of nonwords has a correlation with vocabulary (Gathercole & Baddeley, 1993). This implies that the knowledge of letters-to-sound correspondence rules gives an advantage to Japanese learners in learning unknown words, a fact which was made clear in this study, as there was a significant correlation between non-lexical route efficiency and vocabulary size. In addition, vocabulary knowledge correlates highly with reading comprehension (Qian, 1999). These facts can lead us to the conclusion that phonological decoding efficiency has a correlation with reading comprehension.

- The second reason comes from the viewpoint of supporting working memory. Learning to read entails the mastery of two basic operations – decoding (word recognition and phonological decoding) and comprehension (syntactic parsing, semantic processing, schema processing and discourse processing) (Kadota, 2007, chap.3.1). In reading, unknown words are sent to the comprehension stage as well as real words to get syntactic parsing or schema processing. In this process, working memory is needed to retain and process the information of the unknown words.
Even though the words are not in the learner's mental lexicon, subvocal rehearsals in phonological loop, that is, phonological decoding, is needed for the information to get to the comprehension stage quickly. The automatization of decoding will save the recognition resources in working memory and make it possible to have more capacity for storing the necessary intermediate and final products of the reading process. Many theorists suggest that working memory capacity plays a crucial role in reading comprehension (Daneman & Carpenter, 1980).

4.3 Research question (3)

Phonological decoding through non-lexical route proved to be the better predictor of reading comprehension skill. This suggests that holistic memorization of words is less effective than segmental memorization in reading comprehension.

The possible reason for this is that the knowledge of letter-to-sound translation increases learners’ vocabulary more and more though subvocal rehearsals (Kadota, 2007; Brown and Hulme, 1996). As the vocabulary increases, the load of working memory decreases. This would help learners spare more recognition resources for comprehending text.

Then why doesn’t lexical route efficiency have a significant correlation with reading comprehension? When learners are quick and accurate to pronounce known words, that is, when their lexical route efficiency is activated, they can surely access the mental lexicon effectively; it would lead to quick upper-level process. However, as the experiment shows, this lexical route efficiency showed no correlation with vocabulary size. This means that even if lexical route efficiency is activated, it does not help in increasing vocabulary, which is essential to comprehending text.

4.4 Findings and pedagogic implications

The results of this study suggest that in improving the English comprehension skill of Japanese learners, the traditional vocabulary instruction in Japan, which pays little attention to letters-to-sound translation knowledge, should be changed. In many Japanese high schools, in teaching new words, the meanings are mostly concerned while very little emphasis is put on the pronunciation. Japanese learners rarely have opportunities to learn letters-to-sound translation knowledge. A good example is the word quiz, which is commonly used in Japanese academic high schools. In order to increase vocabulary knowledge for a college exam, many high schools give the students a vocabulary book and a regular word quiz. However, students are often assessed only in the spelling and meaning of a word, putting no emphasis on pronunciation. As a result, word learning in both class and through self-study is done holistically and does not give students the knowledge of letters-to-sound translation. For this reason, Japanese learners are faced with exhausting, ineffective and endless memorization in learning a new word (Koda, 2004, chap.5).

What was surprising in this study was that word learning skill had a correlation only with vocabulary size but not with non-lexical route efficiency. Did the subjects memorize new words
without the use of phonological decoding? This is one possibility. The other is that the subjects used their visual learning ability rather than phonological decoding, knowing that their phonological decoding skill was not clear enough to rely on. The latter is more likely because all of the subjects answered in a questionnaire that they had memorized the shown words by not only rehearsing but also imaging the shape. Overall, the correlation between word learning skill and vocabulary size seems to come from the similar methods subjects used to memorize shown words.

5. Conclusion

Phonological decoding ability proves to have correlation with reading comprehension, especially when it is measured by pseudoword pronunciations. From this result, what can be suggested to modify the present English instruction at Japanese high school for learners to acquire better comprehension?

Training students to activate their non-lexical route efficiency appears to be an effective method. One of the best opportunities to do this is when students learn how to pronounce a word. Instructors should encourage learners to pay attention to the letters-to-sound translation of a body so that it can be automatized. There are two valuable results which would come from this idea: firstly, through activating the non-lexical route, it would be possible to increase students' vocabulary and consequently improve reading comprehension skill; secondly, it would help them read aloud in daily English practice by giving them clear knowledge of a word's pronunciation. Helping students to activate the phonological decoding ability, especially the non-lexical route efficiency, may make them feel more relaxed about reading aloud and promote a better learning environment. In a relaxed classroom, English proficiency and reading comprehension are likely to improve even more.

At present, many methods of instruction in Japanese high schools only have the potential to activate the lexical route. However, the lexical route efficiency has no correlation with vocabulary size. Even if learners repeat after the instructor and try to memorize a word holistically, it is hard to send the lexical information to the long-term memory because it is not easy to rehearse in phonological loop, especially when the word is long. Here, the activation of the non-lexical route plays an important role that cannot be substituted by the lexical route because it will help learners learn words effectively. Furthermore, as the non-lexical route is activated, the lexical route might also be activated because according to the results of this study, lexical route efficiency and non-lexical efficiency have correlation.

Overall, there are some flaws with this study. First, the twenty pseudowords in this study cannot tell the complete truth because English has a deep orthography. Second, the pseudowords used in this study included both ambiguous pseudowords derived from bodies typically given an irregular pronunciation and pseudowords derived from consistent word body. For example, ‘kalk’ has two pronunciations; /kalk/according to GPC rule, and /kɔːk/according to the analogy from
rimes. On the other hand, ‘doon’ can only be pronounced /du:n/. The definition of pseudowords based on body should be free from ambiguity in order to make the assessment clearer.

Although the correlation between phonological decoding efficiency and reading comprehension became clear in this study, it is not clear whether this result can be applied to longitudinal study. Further research is needed.

Notes

1), 2) According to the dual-route theory model (Coltheart, 1978), there are two functionally independent means of processing words: one involves access to lexical knowledge (lexical route) and the other involves non-lexical grapheme-to-phoneme conversion rule (non-lexical route).

3) Body is a unit of phonological decoding based on rime. For example, -eam is the body of ‘team.’

References


**Appendices**

Appendix A  Words list used to measure lexical route efficiency

eg. school, long, child, table, city, teacher, story, swim, you, book

Appendix B  Lexical route efficiency preliminary test

eg. long, grape, child, question, table, world, lesson, week, city, teacher

Appendix C  Pseudoword list used to measure non-lexical route efficiency

eg. wame, meap, troom, jine, noach, troud, plink, kray, la1, kalk

Appendix D  Word learning test

eg. Q1 troom jine

1 troom jine  2 troom jine  3 troom jine  4 troom jine

eg. Q2 noach troud

1 noach troud  2 noach troud  3 noach troud  4 noach troud