

## **Word recognition subcomponents and passage level reading in a foreign language**

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### **Abstract**

Despite the growing number of studies highlighting the complex process of acquiring second language (L2) word recognition skills, comparatively little research has examined the relationship between word recognition and passage-level reading ability in L2 learners; further, the existing results are inconclusive. This study aims to help fill the gap. Three word recognition subcomponents (decoding, sight word reading, and lexical meaning access) and general English language ability were examined in terms of their contributions to predicting the reading comprehension and reading rate of Japanese university students learning English. Multiple regression analyses revealed that, in addition to the contribution made by English language ability, lexical meaning access was a significant predictor of both reading comprehension and reading rate, and decoding was a predictor of reading rate only. These results not only supported some previous findings but also added new insight into the influence of efficiency of lexical meaning access to reading comprehension.

**Keywords:** word recognition, decoding, sight word reading, lexical meaning access, reading rate, reading comprehension

Reading is a complex cognitive skill that requires coordination between various components. In this context, the components refer to a range of knowledge and skills that enable successful reading comprehension. Reading-related components are conventionally categorized into two processing clusters: lower-level and higher-level processes (e.g., Fender, 2001; Grabe, 2009; Koda, 1992; Nassaji, 2003). Broadly speaking, the former involves basic linguistic processes such as letter identification, word recognition, syntactic parsing, and proposition encoding; the latter includes cognitive and metacognitive processes such as integrating information within a text, activating and utilizing background knowledge in text meaning construction, making elaborative inferences, monitoring comprehension, and strategic processing.

Although this distinction is not always clear due to the lack of an established list of the lower-level and higher-level processes, these processes can be differentially conceptualized in

terms of the degree to which their components acquire automaticity. Lower-level processes have the potential to be strongly automatized, but higher-level processes generally require attentional resources (Grabe, 2009). Operations involving various reading-related components draw on the limited capacity of our cognitive resources (e.g., Perfetti, 1985; Samuels, 2006; Stanovich, 1980), and lower-level processes inform the operations of higher-level processes; therefore, if the former is slow and laborious and unable to provide quality information to the latter, then passage-level reading comprehension may not be successful. Word recognition constitutes the most fundamental component at the lower level. The present study focuses on this component and discusses the relationship between different word recognition subcomponents and outcomes in English as a foreign language (EFL) reading. The following section contains a review of background literature, beginning from theories of writing systems that are influential in second language (L2) word recognition studies.

### **Cross-linguistic Variation in Writing Systems**

Writing systems are diverse in terms of the basic linguistic units that individual written symbols represent and the regularity of sound-symbol correspondences (orthographic depth) (Cook & Bassetti, 2005). These basic representational units vary from phoneme (alphabets), to syllable (syllabaries such as Japanese kana), to morpheme (logographies such as Chinese characters). These different representational forms require the activation of different cognitive processes in reading. For example, alphabetic texts require the reader to have the skill to assemble phonemes in order to access lexical representations in the memory. Thus, sensitivity to phonemes, which enables readers to segment and manipulate them, is a prerequisite for alphabetic literacy (Koda, 2005). In contrast, logographic symbols represent both morphemes and syllables (Perfetti, 2003), and logographic literacy does not demand the same degree of intraword analysis (analysis of a word into its structural units such as phonemes or morphemes) as does alphabetic reading. Although phonological processing is still involved, logographic reading draws more heavily on holistic visual cues without segmentation (Koda, 2007).

Writing systems also vary in orthographic depth. In orthographically shallow languages, the sound-symbol correspondences are regular and consistent, whereas in orthographically deep languages, an orthographic symbol is mapped onto multiple sounds, or a sound is mapped onto multiple symbols according to different contexts. This means that the correspondences are irregular and inconsistent. From among the alphabetic languages, Finnish and Italian represent the former case; English and French, the latter (Cook & Bassetti, 2005). According to the orthographic depth hypothesis (ODH) (e.g., Frost, 1994; Frost, Katz, & Bentin, 1987), orthographic depth differences influence the cognitive process of word recognition. In a shallow orthography, readers rely more on phonological processing because of the direct and reliable sound-symbol mapping. On the other hand, in a deep orthography, readers rely less on phonological processing than they do on orthographic processing because of the opacity in the relationship between sound and written symbols. The crucial contention of the ODH, therefore, is that differences in orthographic depth determine the dominant type of information (phonology or orthography) used in word recognition.

While the ODH postulates that readers may take different cognitive routes in response to

orthographic properties, the psycholinguistic grain size theory (Ziegler & Goswami, 2005, 2006) explains how differences in orthographic depth result in psycholinguistic units (grain sizes) that readers develop for reading. Due to the transparent sound to symbol mapping, little orthographic information is needed in shallow orthography. Therefore, the grain size in shallow orthographies is small at the phoneme level. However, deep orthographies require larger orthographic units such as syllables, rimes, or morphemes to decode a word, which results in a larger grain size that readers develop in response to the demand of orthography. Readers in deep orthographies, therefore, develop both small and large grain sizes, and adaptively utilize different grain sizes depending on the contexts (Koda, 2007). This theory has been applied to explain cross-linguistic variation in reading acquisition between alphabetic systems of different orthographic depth. These theoretical frameworks have provided foundations for L2 word recognition research to be reviewed in the next section.

### **Studies on L2 Word Recognition**

Broadly speaking, three key issues have attracted researchers' attention in L2 word recognition research: First language (L1) orthographic effect, L2 print input effect, and L2 proficiency effect. The L1 orthographic effect has, for long, been the focus of L2 word recognition research; this focus is warranted considering the dual-language involvement in L2 reading. A number of studies have compared L2 reading performances between contrasting L1 background groups, and they have documented the persistent impact of L1 orthographic properties (e.g., Akamatsu, 1999, 2003, 2005; Brown & Haynes, 1985; Hamada & Koda, 2008, 2010; Koda, 1990, 1998, 1999; Muljani, Koda, & Moates, 1998; Sasaki, 2005; Wade-Wolley, 1999; Wang & Koda, 2005; Wang, Koda, & Perfetti, 2003).

A simple illustration of an expected L1 orthographic effect is that alphabetic L1 background readers may display more sophisticated intraword analytical ability by drawing on phonemic information, while non-alphabetic L1 background readers (typically logographic) may be less capable of drawing on phonemic information and may instead draw more heavily on holistic visual cues. The research contains collective support for this and similar expectations. For example, Akamatsu (1999, 2003) demonstrated that non-alphabetic L1 English as a second language (ESL) readers (Chinese and Japanese) were more adversely affected by the distortion of visual word shapes than alphabetic L1 readers (Persian) in both single word reading and passage reading. Further, alphabetic L1 ESL readers (Korean) were overall more accurate than logographic L1 readers (Chinese) in single English word reading (Hamada & Koda, 2008, 2010; Wang & Koda, 2005); moreover, the Korean group showed phonological interferences (confusion arising from similar sounds regardless of spelling similarity, suggesting a reliance on phonology, e.g., “bare” vs. “beat” to be associated with “bear”), whereas the Chinese group displayed orthographic interferences (confusion arising from similar spellings regardless of phonological similarity, implying a reliance on visual cues, e.g., “beech” vs. “bench” to be associated with “beach”) in a semantic categorization task (Wang, Koda, & Perfetti, 2003).

The second key issue of interest is the L2 print input effect. Studies on this issue aim to investigate the effect of various L2 print input properties on L2 word recognition performance. In contrast to the L1 orthographic effect—which dictates language-specific effects—this issue

deals with the universal aspect of word recognition, independent of L1 influence. Therefore, we expect commonalities in word recognition behaviors among L2 readers with disparate L1 backgrounds. Studies on L2 word recognition have commonly focused on two representative L2 print input properties: word frequency and the regularity of spelling to sound correspondences. The expectation to be tested is whether, irrespective of L1 orthographic background, (1) L2 readers perform better with higher frequency words compared to lower frequency words, and (2) L2 readers show better performance with regularly spelled words compared to exceptionally spelled words. This hypothesis has been confirmed by researchers who have compared alphabetic and non-alphabetic L1 background ESL readers: Chinese and Indonesian (Muljani, Koda, & Moates, 1998); Chinese, Japanese, and Persian (Akamatsu, 2002); and Korean and Chinese (Koda, 1999; Hamada & Koda, 2008; Wang & Koda, 2005).

The third key issue of interest is L2 proficiency or L2 processing experience (e.g., Akamatsu, 1999, 2005; Chikamatsu, 2006; Haynes & Carr, 1990; Muljani, Koda, & Moates, 1998; Shiotsu, 2009). Research has shown the L2 proficiency effect to be clearly observable. Not surprisingly, it was found that more proficient L2 readers are superior in terms of overall performance. However, past studies do not support the view that L2 proficiency has a simple additive effect upon the development of word recognition processes. Akamatsu (2005), for example, compared L1 Japanese ESL (more proficient) and EFL (less proficient) readers. Although the ESL readers read single words more accurately and quickly, the effect of L1 processing strategy did not decrease in accordance with the increase in proficiency; this suggests that the L1 orthographic effect has a strong and lasting influence in shaping L2 word recognition processes. Chikamatsu (2006) studied L1 English learners of Japanese at higher and lower levels of proficiency. The expectation of decreasing reliance on L1 processing strategy at a higher level was supported only in a context-free word recognition task, but not in the passage reading task. The manifestation of the developmental shift toward L2-appropriate strategies does not appear to be uniform at different levels of reading.

These three factors, in combination, affect the L2 word recognition processes, and processing experiences in both L1 and L2 play critical roles in the formation of L2 word recognition skills (e.g., Koda, 2005, 2007). The persistent influence of L1 orthographic properties even among highly advanced L2 readers offers crucial insights for conceptualizing the association between word recognition processes and reading achievement in L2. The fact that L2 readers of comparable L2 proficiency or L2 reading comprehension ability draw on qualitatively different word recognition processes (e.g., Hamada & Koda, 2008, 2010; Koda, 1998; Wang & Koda, 2005; Wang, Koda, & Perfetti, 2003) suggests that such processing differences may not necessarily be related to overall reading achievement. It could also suggest that although L2 readers draw on different word recognition processes in response to their L1 influence, they can still achieve the same level of reading comprehension. If this was the case, pedagogical intervention based on the premise that a particular set of skills and strategies (often used by monolingual L1 readers) that are universally effective might fail to help L2 readers with disparate L1 backgrounds. Therefore, it is crucial to gain a more thorough understanding of how L2 word recognition skills are associated with higher levels of reading achievement. The next section reviews studies in this area.

## **The Relationship between Word Recognition and Passage Reading in L2**

Many studies on the relationship between word recognition and reading outcomes have adopted a component skills approach (Carr & Levy, 1990) where various reading-related components, including word recognition skills, are tested in terms of their contribution to reading ability. For efficiency, this review focuses on the relationship between word recognition and passage reading performance.

Haynes and Carr (1990) measured four types of word processing skills in L1 Chinese EFL readers (Taiwanese university students): real words, orthographically plausible pseudowords, orthographically implausible letter strings, and lexical semantic access (efficiency of access to lexical meanings). The efficiency of lexical semantic access explained the largest amount (17.88%) of individual differences in reading rate. None of the word recognition subcomponents, however, showed statistically significant associations with reading comprehension.

Nassaji and Geva (1999) studied L1 Farsi (alphabetic) graduate ESL students. Efficiency in phonological processing and orthographic processing accounted for 24% of the variance in reading comprehension and 21% of the variance in reading rate.

Four studies conducted on L1 Dutch EFL learners reported mixed results. Van Gelderen, Schoonen, de Glopper, Hulstijn, Simis, Snellings, and Stevenson (2004) and van Gelderen, Schoonen, de Glopper, Hulstijn, Snellings, Simis, and Stevenson (2003) examined the influence of word recognition skills on EFL reading comprehension in grade 8 students. In both studies, real word recognition speed did not explain variance in the individual differences in English reading comprehension. Fukkink, Hulstijn, and Simis (2005) gave grade 8 students computer-based training aimed at facilitating the automatization of word recognition. Although this training aided word recognition skills, it did not transfer to the improvement of reading speed or reading comprehension. However, a longitudinal study conducted on students in grades 8–10 (Van Gelderen, Schoonen, Stoel, Glopper, and Hulstijn, 2007) revealed that real word recognition speed had a significant effect on L2 reading comprehension in grade 8. This effect, however, disappeared in grades 9 and 10.

The following three studies were conducted on L1 Japanese EFL learners. Kato (2009), who studied university students, found that phonological processing was found to be correlated with sentence reading rate and orthographic processing was correlated with sentence reading comprehension. Shiotsu (2010), who also examined university students, found that only the lexicality effect (the difference between pseudoword and real word processing efficiency) made a statistically significant but minor contribution to reading comprehension. However, lexical semantic access and real word processing efficiency significantly explained the sentence reading speed, with the former being more strongly related to speed than the latter. Fujita's (2010) study of grade 10 students showed that none of the word recognition subcomponents (phonological, orthographic, and sight word processing) explained the variance in reading comprehension, however, phonological processing and sight word processing contributed significantly to reading rate.

Finally, two cross-linguistic studies offer intriguing insights into the disparate relationships

between word recognition and reading achievement for L2 readers with different L1 backgrounds. Koda (1998) examined the relationships among phoneme awareness, decoding, and reading comprehension in Chinese and Korean ESL learners. Phoneme awareness and decoding were correlated with reading comprehension and decoding explained nearly half of the variances in the reading comprehension of the Koreans. In contrast, neither of these two lower level skills correlated with reading comprehension for the Chinese group nor explained the variance in this group's reading comprehension. Hamada and Koda (2010) compared alphabetic L1 (Korean and Turkish) and non-alphabetic L1 (Chinese and Japanese) ESL readers in terms of their L2 decoding efficiency and word meaning inference. Of interest here is the researchers' documentation of correlation patterns between decoding efficiency and reading comprehension scores between the two groups. Although there was no group difference with regard to pseudoword decoding, a distinct result appeared in real word decoding with the correlation being significant for the alphabetic L1 group but not significant for the non-alphabetic L1 group.

Viewed collectively, the literature suggests that it is still difficult to arrive at a consensus because of different conceptualizations of word recognition subcomponents, different methods for measuring them, and varying findings by past studies. However, these studies have suggested the impact of readers' L1 orthographic backgrounds on how word recognition subcomponents relate to reading outcomes. When L2 was English and L1 was another alphabetic language, word recognition skills were associated with reading comprehension (Hamada & Koda, 2008; Koda, 1998; Nassaji & Geva, 1999) and reading rate (Nassaji & Geva, 1999). However, when L1 was a non-alphabetic language, word recognition skills did not exhibit a significant influence on reading comprehension (Hamada & Koda, 2008; Koda, 1998; Fujita, 2010; Haynes & Carr, 1990; Shiotsu, 2010), but instead contributed to reading rate (Fujita, 2010; Haynes & Carr, 1990; Shiotsu, 2010). There are conflicting findings, however, with regard to this tentative summation (Kato, 2009; Van Gelderen et al., 2003, 2004) and further investigation will definitely be beneficial.

## **Research Questions**

Based on insights from the literature suggesting different impacts of word recognition subcomponents on reading comprehension and reading rate, the following research questions were addressed.

1. Which word recognition subcomponents explain individual differences in L2 reading comprehension?
2. Which word recognition subcomponents explain individual differences in L2 reading rate?

## **Method**

### *Participants*

The participants comprised 102 Japanese EFL university students who studied English for six to seven years through formal education at school.

### *Design*

The study involved two aspects of passage-level reading ability (comprehension and reading rate) as criterion (dependent) variables and three subcomponents of word recognition (decoding, sight word reading, and lexical meaning access) as well as English language ability as predictor (independent) variables. Decoding is the process of transforming written symbols to their phonological forms and essentially to language. Various foundational skills that facilitate intraword analytical ability in English—such as phonological awareness, mapping between letters and their names, and mapping between graphemes and their phonological representations—are prerequisites for developing this fundamental skill for reading (Koda, 2005). The activation of phonological information in word recognition is not only obligatory in alphabetic languages such as English (Stanovich, 1991), but also universal (Perfetti, 2003) in the sense that phonological processing is involved in any writing system when readers read a word.

Sight words refer to individual words that readers can read by sight from memory; such words are read quickly and accurately in isolation as well as in texts because the pronunciation and meaning of these words are activated even with a quick glance (Ehri, 2005). Sight word reading ability is built upon a solid decoding ability (Aaron et al., 1999) and sight words are secured in the mental lexicon by means of established connections between graphemes and phonemes in memory. Further development in sight word reading involves the unitization of linguistic units. Blends of graphophonemic units such as morphemes, onsets and rimes, and monosyllabic words are stored in the memory as consolidated units. These units are then utilized when reading larger units like polysyllabic words. The unitization of units helps readers to read a consolidated unit as a whole and reduce memory load (Ehri, 2005).

Lexical meaning access refers to the access to word meanings in memory. With a small number of exceptions, research on L2 word recognition has not included this variable. However, there is an extensive body of psycholinguistic research demonstrating that the connection between word forms and concepts in L2 is weaker than that in L1 (e.g., Dufour & Kroll, 1995; Kroll, 1993; Kroll & Stewart, 1994; Kroll & Tokowicz, 2001). This weaker connection in L2 could be attributed to a unique process of L2 vocabulary acquisition. Unlike the case with children, adult L2 learners have already acquired concepts in L1 and they can easily access an L2 word meaning by using an L1 translation. Therefore, L2 vocabulary acquisition is often a process of mapping new L2 word forms to already known meanings. It is possible that this process facilitates the initial stage of L2 vocabulary acquisition, but the existing L1 system may delay the direct mapping between L2 word forms and their meanings (Jiang, 2000). Although sight word reading would always involve meaning access in L1 due to automatized form-meaning connections in the mental lexicon, tasks measuring sight word reading do not usually mandate meaning activation and may not be sensitive enough to measure the meaning manipulation process. Therefore, another test that invariably requires meaning activation was incorporated in this study.

In addition to the three word recognition subcomponents, L2 language ability was included as one of the predictor variables because L2 language ability bears primary importance for the achievement of L2 reading comprehension (e.g., Berhardt & Kamil, 1995; Bossers, 1991; Carrell, 1991; Lee & Shallert, 1997; Taillefer, 1996; Yamashita, 2002). L2 language ability was used as a covariate to determine whether word recognition subcomponents make a unique contribution to

L2 reading in addition to this powerful component of L2 reading.

### *Materials*

*Reading comprehension.* Reading comprehension ability was measured using the Extensive Reading Test developed by the Edinburgh Project in Extensive Reading (EPER). This test was selected in accordance with another project that was concurrently in progress with the present study. This test was originally constructed for use in extensive reading programs to measure reading comprehension ability (Davis & Irvine, 1996). The test consists of eight bands at different levels. Based on the author's experience in using this test in past years, levels B & C (version 1) were employed. At each level, there was a relatively long narrative story (1663 and 1460 words in level B and C, respectively) with associated short-answer and gap-filling-summary comprehension questions. There were 41 questions with a total score of 60. Internal consistencies (Cronbach's alpha) were .85 (with a correct answer score of one) and .82 (with a correct answer given a prescribed score weight).

*Reading rate.* The reading rate was conceptualized based on Carver (1990, 2000), according to whom reading rate is constant when readers read texts well within their reading ability in order to understand the texts' general meaning. The expected comprehension level is said to be over 64% (Carver, 2000).

The passages used to measure individuals' reading rates were selected from a pool of retired copies of The Eiken Test in Practical English Proficiency, a standardized test of English proficiency constructed by the Society for Testing English Proficiency (STEP). This set of tests, which currently involves seven bands, has been widely used in Japan. Each band corresponds to a different school grade, with the pre-first grade approximating the intermediate university level. Candidate passages selected from this grade were originally used for the listening comprehension section, but these seemed to better serve the present purpose than those in the reading section because of their linguistic simplicity. From among the candidate passages, two descriptive style texts were finally chosen. The contents were about the health effects of a short nap and the decrease in movie theater attendance, both of which were judged as neutral in terms of the background knowledge of the readers. The lengths of the passages were 145 and 141 words, respectively, and the correlation between the two reading rates measures was .75.

Two multiple-choice comprehension questions per passage in the original test were adopted to encourage readers to read with comprehension. The questions were answered after reading without reference to the passage. Each correct answer was assigned a score of one. The mean comprehension score was 67% (2.66,  $SD = 0.97$ ), which exceeded Carver's (2000) proposal of 64%.

When estimating reading rates, three different methods were initially undertaken in order to see the variation between estimation methods. The default position was simply to adopt the means of the two passages. The second method did not count reading rate records when students' comprehension score was zero. In such cases, an individual's reading rate was taken as the result of only one passage. The third, and most stringent, method included reading rates only when students gained full scores. Correlations between these three possible estimates were all higher



than .95, and based on that, this study employed the first, default method.

*L2 language ability.* In order to measure English language ability, a cloze test was used. This test was created by simplifying one of the placement/progress tests originally constructed by the EPER. The original test consists of 147 items based on 13 short passages (approximately 80 words each) and aims to measure a complete range of English language proficiency levels (EPER, n.d.). Although some reading comprehension ability may be required to complete the test, the level of comprehension is more likely to be at the local level (use of grammatical and lexical constraints) rather than the text level (use of text-level constraints). This is in marked contrast to the aforementioned reading comprehension test, which clearly requires the ability to comprehend lengthy coherent stories. Based on a pool of data collected in the past from a population of Japanese EFL learners similar to the current participants, items contributing to the test's internal consistency were selected; the final result was in a 58-item test based on five passages (see Yamashita & Ichikawa, 2010, for more details). Each correct answer was assigned a score of one. The Cronbach's alpha was .66.

*Word recognition.* Timed dichotomous judgment tasks were used to test the aforementioned three subcomponents of word recognition skills. In addition, a digit task was included to control for the possible task effect, similar to the cases in Haynes and Carr (1990) and Shiotsu (2010). The digit task was a same-different judgment task. Eighty pairs of three digits (e.g., 957-957, 297-397) were printed on a sheet of paper. The readers had to judge whether the two numbers were identical or not and circle either the "Yes" or "No" options printed beside each pair.

Decoding and sight word reading skills were measured using a lexical judgment task.<sup>1</sup> Half of the stimuli were taken from Form A of the Test of Word Reading Efficiency (TOWRE: Torgesen, Wagner, & Rashotte, 1999). This test provides estimates of two kinds of word recognition efficiency: sight word reading and phonemic decoding. Although the original test calls for orally reading a list of words for 45 seconds and uses the number of correctly read items as the score, in this study, this test was converted into a judgment task response on a sheet of paper in order to make group administration possible. The scoring method, however, remained identical (i.e., the total number of correct responses). There are 104 real words (content words such as nouns, verbs, and adjectives and function words such as prepositions, pronouns, and articles) and 63 pseudowords (pronounceable letter strings consisting of orthographically plausible letter combinations) in the original test. In addition to the TOWRE stimuli, the author created another 104 pseudowords and 63 nonwords (unpronounceable letter strings consisting of orthographically implausible letter combinations) using the ARC Nonword Database (<http://www.macqs.mq.edu.au/~nwdb/>) and WordGen (Duyck et al., 2004).

The decoding test consisted of the original 63 pseudowords from TOWRE and the 63 newly created nonwords ( $k = 126$ ). These two types of words were randomized and presented as a single word list. The task for the reader was to make a "yes" or "no" judgment regarding whether or not an item could be an English word (i.e., whether an item can be read as an English word) despite the fact that all items were non-existing words. Due to copyright restrictions, only a limited number of examples taken from the practice trial are shown here: ba, gy, fos, qru, rup, oifm, luddy. Similarly, the sight word reading test consisted of 104 real words from TOWRE and 104 pseudowords created for this study ( $k = 208$ ), which were randomized and presented as a

single list (e.g., on, my, vem, old, glok, bone, pusuk). The reader's task again was to make a dichotomous judgment regarding whether an item in the list was a real English word or not. When creating word lists, blocked randomization was employed in order to control for the length of items so that the lists started with short words (two letters) that gradually became longer (10 letters). Preliminary word lists were pilot tested with three native speakers of English. Several items to which two or more of the native speakers responded against expectations were changed. The new items were tested again and their adequacy was finally confirmed.

The sight word reading task aimed to measure the efficiency of the holistic processing of real words, where readers make use of a direct mapping between visual stimuli and entries in their mental lexicon. The decoding task, by contrast, intended to measure the efficiency of phonologically mediated processing. Pseudowords force readers to read a stimulus using grapheme-phoneme-correspondence rules. Although we cannot completely exclude the involvement of phonological processing in sight word reading, different kinds of stimuli (real words vs. pseudowords) help measure different abilities involved in word recognition to the maximum degree possible.

Lexical meaning access was measured by using items created by Kojima (2010). Each item constituted a pair of words listed side by side (e.g., large-still, mind-body, die-make, last-alone, wife-husband, clean-dirty). In the original test, 128 pairs of items were constructed, controlling for frequency, familiarity, and word length. For the current study, 89 pairs of words were selected on the basis a pilot study. The words in all pairs were within the most frequent 2000-word level in the JACET List of 8000 Basic Words (JACET Committee of Basic Words Revision, 2003). This is the beginning level for high school students in the Japanese education system, and therefore the words were assumed to be known to the participants. The list consisted of pairs of content words such as nouns, verbs, adjectives, and adverbs. The task was to make a dichotomous judgment on whether or not the two words were antonyms.

Each list was printed on a sheet of paper along with the instructions and practice items. The tasks were given in the following order: digit, sight word, decoding, and meaning access. The participants were asked to respond as quickly and accurately as possible. They were also asked not to use an eraser, and if they made a mistake, they had to cross it out and circle the correct answer; this is because erasing adds time that is irrelevant to the purpose of this study. The time limit for each task was set at one minute, and scores on each test represented the number of correct responses each participant made within the time limit. For this type of speed test, alternate-form reliability should ideally be used to examine internal consistency (Torgesen, Wagner, & Rashotte, 1999), but the alternate form was not administered. As a rough estimate, split-half reliabilities (correlation between even and odd item scores) are reported; .98 (digit), .91 (decoding), .97 (sight word), and .86 (meaning access).

In general, high accuracy rates were expected from these judgment tasks because the intention was not to measure participants' knowledge but rather their efficiency in using this knowledge during cognitive processes.

### *Procedure*

Tests were administered by the author over three consecutive weeks in groups of 20 to 40 participants. The English language ability test was administered in the first week, the reading comprehension test in the second, and the reading rate and word recognition tests in the third. An assistant helped in the administration of the speed related tests to ensure as accurate a measurement as possible. Close attention was paid to the participants' performance during the speeded word recognition tests. No anomalous behaviors were observed. The reading rate was measured by the participants using a stopwatch. They switched it on at the start of their reading, stopped it when finished, and recorded the time on a sheet of paper. Before the task, they practiced using the stopwatch. No difficulty was reported and careful observation during the task did not detect any failures in the measuring of rates.

### *Data screening*

Data from students who did not complete all tests were eliminated ( $n=16$ ). A preliminary inspection of the responses of the remaining students in the word recognition tasks revealed high accuracy rates, as expected. However, there were some students who scored around the chance level (50%). These students may not have correctly understood the task, because most of these cases took place in the decoding task and making decisions regarding non-existing words was probably more confusing than was the case with real words. Therefore, data was removed if the accuracy rates were below 70% (four in the decoding task and one in the meaning access task).<sup>2</sup>

Deviation from the normal distribution was corrected either by deleting outliers or by data transformation. Two outlier cases (more than 2.5 *SDs* away from the mean), one each in the digit and decoding tasks, were deleted, which improved the distribution. A square root transformation was applied to the measures of English ability, reading rate, and sight word reading, which improved the distribution of the first two variables. However, the scores for the sight word reading were either negatively skewed without transformation or severely peaked with transformation; in the end, transformation was not applied. After these steps of data screening, the final sample size was 79.

## **Results**

### *Descriptive statistics*

Table 1 lists the descriptive statistics. As already mentioned, the accuracy rates for the digit, sight word reading, decoding, and meaning access tasks were high: 99.68 ( $SD = 0.99$ ), 99.70 ( $SD = 0.84$ ), 88.93 ( $SD = 6.48$ ), and 89.42 ( $SD = 6.77$ ), respectively. These high accuracy rates indicate that the main source of score variation was not accuracy but speed of performance.

Table 1. *Descriptive statistics for reading comprehension, reading rate, L2 language ability and speeded recognition tasks*

	<i>M</i>	<i>SD</i>	95% CI	Skew	Kurt
Reading comprehension	35.21	9.30	[33.13, 37.29]	0.45	-0.4
English ability	15.80	4.41	[14.81, 16.78]	0.57	0.8
Reading rate (wpm)	116.44	23.05	[111.28, 121.60]	0.56	0.38
<b>Speeded recognition</b>					
Digit	33.13	3.92	[32.25, 34.00]	-0.13	-0.34
Decoding	26.68	4.54	[25.67, 27.70]	-0.03	-0.02
Sight word reading	35.53	4.54	[34.52, 36.55]	-0.75	0.17
Meaning access	16.41	2.84	[15.77, 17.04]	-0.22	-0.67

Note: CI = confidence interval. wpm = words per minute

### Correlations

Table 2 displays the correlations among the variables. Reading comprehension and reading rate correlated moderately ( $r = .40$ ) and there were correlations with different sets of predictor variables. English ability correlated with comprehension and rate, but the stronger correlation with comprehension. Four timed processing tasks correlated moderately ( $r = .38$  to  $.53$ ), which suggests the existence of a task specific effect, supporting the use of the digit score as a covariate. Although none of the correlations were as high as to suggest multicollinearity, sight word reading measurement did not significantly correlate with any of the criterion variables. This could partly be due to skewed distribution. Due to the lack of reliable correlations, sight word reading was not included in the multiple regression analyses, discussed below.

Table 2. *Bivariate correlations between all variables*

	1	2	3	4	5	6
1. Reading comprehension	-					
2. English ability	.52**	-				
3. Reading rate (wpm)	.40**	.31**	-			
4. Digit	.10	.11	.38**	-		
5. Decoding	.12	.08	.48**	.50**	-	
6. Sight word reading	-.13	.01	.17	.53**	.48**	-
7. Meaning access	.31**	.18	.53**	.44**	.50**	.35**

Note: \*\*  $p < .01$

### Multiple regression analysis

Multiple regression analyses were employed to determine the relative contribution of the predictor variables to the criterion variables. In all of the analyses reported below, assumptions of normality of residuals was affirmed (standard residuals between -3.0 and 3.0), multicollinearity was not a concern (Cook's distance all below 1.0), and no obvious outliers were identified (VIF all below 2.0) (Larson- Hall, 2010).

Two kinds of hierarchical multiple regression were performed, one using a three-step analysis and the other, a two-step analysis. The digit task score was first entered into the equation as a covariate to control for a possible task effect on word recognition variables that is irrelevant to linguistic processing. In the three-step hierarchical regression, English ability was entered into the analysis in the second step; then, the two word recognition variables (decoding and meaning access) were simultaneously entered in the final step. This model intended to examine whether word recognition subcomponents make unique contributions to reading ability after English ability has played its role in explaining the variance shared with the criterion variable. This analysis makes a strong case for word recognition variables if they appear as significant predictors; however, it may also underestimate their contribution. Therefore, the two-step analysis was employed as a supplementary analysis by entering only word recognition variables in the second step. This model intended to identify the contribution made by word recognition without English ability explaining any shared variance with the criterion variable (Tabachnik & Fidel, 2007). Both analyses resulted in reliable models and there was no difference in the results in terms of the significant predictors and their relative weights. This indicated that word recognition variables made a unique contribution, in addition to the contribution of English ability, to explaining variance in reading outcomes. Therefore, results from the three-step analyses are reported in this paper.

Table 3 summarizes the results. Only statistically significant variables ( $p < .05$ ) are listed for Steps 2 and 3. In the model tested for reading comprehension ( $F_{(4,74)}=8.80, p = .000$ . Adjusted  $R^2 = .29$ ), English language ability and meaning access appeared to be significant predictors, with the former being a much stronger predictor than the latter ( $\beta = .48$  vs.  $.25$ ). For the reading rate ( $F_{(4,74)}=11.93, p = .000$ . Adjusted  $R^2 = .36$ ), meaning access, decoding, and English ability were all significant predictors ( $\beta = .32, .25$ , and  $.22$ , respectively). Unlike the case with reading comprehension, word recognition subcomponents were stronger predictors than English ability.

Table 3. *Summary of Multiple Regression analyses for reading comprehension and reading rate as criterion variables*

Criterion variable		Predictor variable	$\Delta R^2$	$B$	$SE(B)$	$\beta$	$p$
Reading comprehension	Step 1	Digit	.010	0.236	0.269	.100	.382
	Step 2	English ability	.265	8.642	1.639	.518	.000
	Step 3	English ability	.047	8.064	1.626	.483	.000
		Meaning access		0.816	0.378	.249	.034
Reading rate (wpm)	Step 1	Digit	.147	0.103	0.028	.383	.000
	Step 2	Digit	.071	0.096	0.028	.355	.001
		English ability		0.510	0.194	.269	.010
	Step 3	English ability	.174	0.413	0.175	.218	.021
		Decoding		0.059	0.026	.252	.028
		Meaning access		0.120	0.041	.321	.004

## Discussion

The multiple regression analyses focused on two word recognition subcomponents (decoding and meaning access) and examined their contributions to two aspects of passage-level reading ability (comprehension and reading rate). For reading comprehension, only meaning access emerged as a significant predictor, whereas for reading rate, both meaning access and decoding were significant predictors.

Characteristics of the current participants inevitably determine the scope of this study. In terms of the three key issues of L2 word recognition research discussed previously, this study has expanded upon the case of non-alphabetic L1 readers reading alphabetic L2 when L2 print exposure is limited in a foreign language context and the readers' L2 proficiency is best described as intermediate (see Akamatsu's [2005] contrasted between Japanese EFL and ESL learners).

Given this contextualization, the current results were both in agreement with and divergent from previous findings. First, the result lent support to the differential contribution of decoding or phonological processing to reading comprehension and reading rate, that is, decoding was associated with reading rate but not with reading comprehension (Fujita, 2010; Hamada & Koda, 2010; Kato 2009; Koda, 1998). The results were also in accordance with a previous finding that lexical meaning access predicts reading rate (Haynes & Carr, 1990; Shiotsu, 2010). However, only the current study identified the contribution of meaning access to reading comprehension, in contrast to the outcomes of previous studies (Haynes & Carr, 1990; Shiotsu, 2010). A possible reason for this unique finding is that the meaning access in this study may have measured individual differences in vocabulary knowledge rather than processing efficiency. This speculation can be affirmed if the accuracy rate of the current measurement is considerably lower and varied than those in previous studies. This possibility could only be tested against the findings of Shiotsu (2010), who reported on accuracy rate. In his study, the accuracy rate was .91 ( $SD = .09$ ) and in this study it was .89 ( $SD = .07$ ). With around 90% of accuracy with fairly small within-group variation, it can be said that both studies measured processing efficiency rather than vocabulary knowledge. Therefore, the above conjecture does not have grounding. A new insight from this study is that efficiency in accessing lexical meanings in the L2 mental lexicon is important not only for the reading rate but also for reading comprehension. This seems reasonable because reading comprehension is a meaning construction process and lexical meaning is one of the smallest semantic units used in this process.

As mentioned above, research on the contribution of L2 word recognition skills to reading ability has rarely included the semantic aspect of processing. This does not imply in any way that L2 reading researchers are ignorant of this aspect (e.g., Koda 2005; Grabe, 2009). Rather it may be due to the fact that L2 studies are often founded upon L1 research and L1 studies do not usually explicitly measure semantic processing because a real word recognition task is supposedly sufficient to activate the lexical meaning due to strong connections between word forms and meanings. As discussed earlier, however, this is not always the case for L2 learners. The semantic component in word recognition would deserve more attention in this line of research.

The decoding results underscored past findings. The non-significant contribution of decoding to

reading comprehension contrasts sharply with the results obtained for ESL readers with alphabetic L1 (Koda 1998; Nassaji & Geva, 1999). As many L2 word recognition studies have shown, during reading comprehension, readers with non-alphabetic L1 may not be utilizing phonological information in the same manner as those with alphabetic L1. However, it is still too early to conclude that decoding is not important for EFL readers with the non-alphabetic L1 backgrounds. Since there was a moderate correlation between comprehension and reading rate, it is possible that decoding makes an indirect contribution to comprehension via the reading rate. It is also possible that decoding may help comprehension via other variables such as word learning (Hamada & Koda, 2008). A more in-depth analysis is required to clarify this possible indirect association.

This study has some limitations that will benefit future studies. First, word recognition and reading rate measures could be made more precise by using computers. Second, the lexical decision task used for the sight word measure did not function well in this study. Considering the negatively skewed distribution, items may have been too simple for this population of learners or we may have needed more time to make participants read more items in order to detect individual differences. In addition, interactions among predictor and criterion variables are needless to say, complex as they include not only direct relationships but also indirect relationships such as the one discussed above. These complex interactions are difficult to examine with multiple regression analyses. A path analysis or structural equation modeling could provide a more beneficial investigation of complex relationships (Tabachnick & Fidell, 2007); the use of experimental designs to directly manipulate target components and examine potential interactions may also be a useful approach. Another consideration is the developmental issue. Components explaining individual differences in reading outcomes change over the course of development. Cross-sectional and, ideally, longitudinal studies on the shift in the importance of word recognition subcomponents will greatly elucidate our understanding of their roles.

## **Conclusion**

Despite the amount of research directed toward understanding L2 word recognition processes, per se, there remains comparatively limited evidence available from previous studies on the relationship between word recognition and passage-level reading abilities in L2. An interesting contrast in the research design in studies dealing with these two related but different research agendas is that the majority of L2 word recognition research is cross-linguistic, involving L2 readers with multiple L1 backgrounds, while the latter group of studies includes L2 readers from a single L1 background, with Koda (1998) being the only notable exception. Since the previous literature implies that different word recognition processes may be associated with passage-level reading for L2 readers of distinct L1 backgrounds, research into the relationship between word recognition and reading outcomes should also make efforts to make the design cross-linguistic. Alternatively, more studies should expand the pool of readers of single but disparate L1 backgrounds so as to obtain a sufficient body of evidence for cross-linguistic comparisons.

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## Notes

1. Although a lexical judgment task may be an indirect measure of phonological processing in comparison with a naming task that requires the oral production of stimuli, various judgment tasks have been used in research to measure decoding and sight word reading skills (e.g., Kato, 2009; Nassaji, 2003; Nassaji & Geva, 1999; Olson, Kliegl, Davidson, & Foltz, 1984; Van Gelderen et al., 2003, 2004). Further, naming tasks may result in problems for L2 readers if they have difficulty in articulating English-specific phonemes that do not exist in their L1 (Nassaji, 2003). For this reason, a judgment task was employed in this study.

2. Initially, the analyses of speed recognition tasks were conducted using scores from all items and from only positive-items (items expecting “yes” responses). There was virtually no difference in the results; this paper reports the latter result because this method was more conceptually fine-tuned by representing readers’ decisions on real words and decodable letter strings excluding non-existing words and implausible letter strings. Therefore, data screening was based on the accuracy rates of positive-item scores.

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