Visual, Lexical, and Contextual Effects on Word Identification of Korean

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Abstract

In order to assess the role of visual, lexical, and contextual information on word identification during Korean sentence reading, a self-paced reading experiment was conducted. It was found, in regard to word length variables, that the number of syllables and the number of visual features affected reading times significantly, but the other sub-lexical units (i.e., phonemes and letters) did not. Word length (i.e., the number of syllable) also interacted with word frequency, which is consistent with previous studies. It suggested a conclusion that in Korean the relevant processing unit, in the context of sentence, is the syllable, taking internal structure variations into account. Word frequency and predictability affected reading times respectively; however, the interaction between these two variables did not. The results imply that Korean word identification during reading can be possibly affected by word frequency and word predictability, additively. This result is consistent with recent eye-tracking studies using English.

Keywords: word length; word frequency; context effect; word identification; Korean

Introduction

Does word identification occur in the same way regardless of language specifics (e.g., alphabetic language or non-alphabetic language) or the situation of word identification (e.g., word in isolation or word in text)? In order to answer this question, the present study focuses on Korean word identification for cross-linguistic comparisons and to examine the process of word identification during the reading of a sentence, not just a word in isolation.

To examine the degree to which language-specific factors and contextual factors in a sentence affect word identification, this current study examined how word identification is affected by three main variables: word length, frequency, and predictability. This study used Korean to allow comparisons with other languages (e.g., English) and the self-paced reading of sentences to address the following four research questions: First, what are the basic units of processing (e.g., letters, syllables, and/or words) during the reading of Korean? Second, to what degree do lexical variable (e.g., word frequency) play a role in the reading of Korean? Third, to how much do the sentential constraints imposed by syntax and/or meaning (i.e., word predictability) affect word identification during the reading of Korean? Finally, how do the three main variables of interest (word length, frequency, and predictability) interact with each other?

The Korean Writing System and Sentence Structure

In order to illustrate the characteristic processes in Korean word identification, writing system of Korean should be reviewed briefly. The Korean alphabet, Hangul, consists of 24 primary letters, with 14 consonants and 10 vowels. It is considered an *alphabetic syllabary* because each phoneme is represented by a letter, and each word is made from letters that are combined into syllables that consist of compact character blocks as in Figure 1 (see Taylor, 1980).

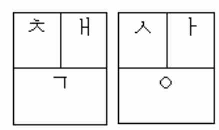

Figure 1: Spatial arrangement of letters in Korean syllables and words, "chayk sang"[1] (desk in English) with the left-most "box" containing the first CVC syllable (i.e., the letters, ㅊ, ㅐ, ㄱ), and the right-most "box" containing the second CVC syllable (i.e., the letters, ㅅ, ㅏ, ㅇ).

As the Figure 1 shows, each syllable begins with a consonant, and has at least one additional consonant and one vowel, which may represent a CV, CVC, or CVCC syllable. Because of its one-to-one correspondence between letters and phonemes, Korean does not have some of the confusions that exist in English. For instance, in English, a single letter can represent a variety of sounds, and a single sound can be represented by several different letters or letter group (Taylor, 1980).

At a higher, linguistic level, Korean sentence structure is different from many other commonly studied languages (e.g., English) in that it is head-final, which simply means that verbs are placed at the ends of sentences (i.e., SOV word order). In addition, due to case markers, word order in sentences is thus more flexible than in English, and syntactic categories are represented using by case markers (e.g., '*는–nun*' for the subject and '*를–lul*' for the object in Example 1).

Example (1)

선주는*	낚시를*	좋아한다.
SeonJoo*nun**	Nakksi*lul**	cohahanta.
SeonJoo	fishing	likes

These important characteristics of Korean may influence the word predictability effect because it is determined – at

[1] All transliterations in this article follow the Yale Romanization System (Martin, 1992).

least in part – by the syntactic information that occurs prior to a given word. Thus, one might predict that, in the case of Korean, the head-final syntactic structure and the use of case markers might together provide different contextual constraints on each word in a sentence, especially weak syntactic constraints, and thereby reduce the overall size of any word predictability effects that might be observed in the present experiment.

Previous Findings

First, word length is thought of as a fundamental constraint to identify a word, which supported by results of many different languages, such as Korean (Park, 1993; Nam et al., 1997), English (Lee, 1999), Hebrew (Lavidor & Whitney, 2005), and French (Juphard, Carbonnel, & Valdois, 2004). These studies have generally found that naming and lexical-decision latencies for target words are longer for long words than for short words. This result is thought to be due to the fact that our visual system has limited visual acuity which makes it more difficult to identify larger objects (e.g., words). In addition, the tasks demand cognitive processes, for instance, matching the printed scripts to their sounds. If the time to complete these processes increases linearly as word length increases, then it would take more time to name long words than short words.

In terms of the internal structure of Korean words, there are two properties of the Korean alphabet (*Hangul*) system: the first is the different types of CV blocks in a word (Taylor, 1980); the second is the number of visual features making up letters and words. In Hangul, the square-like spatial arrangements of the individual letters within each syllable may possibly relate to the complexity of a word, because there can be relative variation of the visual features or the CV block types in the limited space. There are five different CV combination types that can be categorized into three levels of visual complexity (see Table 1).

Basically, the complexity increased by adding a consonant might affect word identification simply because increasing the complexity of a word increases the number of visual features, and thereby induces more low-level visual processing necessary to identify the word.

Table 1: Example of Hangul Syllable Blocks Showing Three Levels of Complexity (adapted from Taylor (1980) with permission of Springer Publisher) and Number of Visual Features (added by the author).

Complexity Level	Linear Arrangement	Syllable-Block	Number of Feature	Syllable & pronunciation	Meaning
I	ㅏ	아	3	V /a/	suffix; ah
I	ㄷㅏ	다	5	CV /da/	All
II	ㅏㄹ	알	8	VC /al/	Egg
II	ㄷㅏㄹ	달	10	CVC /dal/	Moon
III	ㄷㅏㄹㄱ	닭	12	CVCC /dalg/	Hen

Nam and colleagues (1997) found the role of sublexical units in Korean as well as visual features, such as horizontal, vertical, and diagonal lines, and circles (examples shown in Table 1) using naming and lexical-decision tasks. The result showed that the reaction times increased as the number of visual features in the words increased, even when the number of syllables was controlled. It may reflect the fact that native speakers of Korean are sensitive to the visual complexity of words, even though these visual features are not related to the linguistic aspects of the language.

Based on the internal structure of a Korean word, one might still ask whether or not the CV blocks and/or visual components of the letters (e.g., vertical lines) have a role in word identification within text. Although a couple of previous studies dealt with characteristics of the internal structure of Korean, neither tested its effect on during word identification during a reading of sentence: Taylor (1980) used non-language task and Nam et al. (1997) used recognition task of isolated words. Task differences might be expected to induce a specific priority in word identification, for example, compared to silent reading task, the naming task possibly requires that readers access phonological information from printed words.

The second variable considered in the present study is frequency of occurrence. Many previous studies using a variety of different experimental methods have consistently demonstrated word frequency effects (Monsell, Doyle, & Haggard, 1989; Allen, McNeal, & Kvak, 1992). Allen et al. (1992) examined the effect of word frequency by manipulating stimulus onset asynchrony (SOA), the interval between onset of the prime and the onset of the target. In their lexical decision experiments, word-frequency effects were found across the different SOAs, between the presentation of a letter string and a subsequent pattern mask in a lexical decision task, with no interaction between frequency and SOA. In addition, Monsell et al. (1989) designed a series of experiments to compare the effect of word frequency using different types of tasks (e.g., semantic categorization, syntactic categorization, etc.), and showed a consistent word-frequency effect in lexical identification with little variability of its effect size. Together, these results suggest that word frequency effects are robust, and can be expected across languages, because this process can be achieved by a language-independent mechanism.

A more interesting aspect of frequency could be its relationship with other variables in a word. For example, Lee (1999) found an interaction between frequency and word length with native English speakers, with larger word-length effects for low-frequency than high-frequency words. Studies of Korean have also reported this kind of interaction (Choi, 1986; Park, 1993; Nam et al., 1997). For example, Park (1993) showed a larger frequency effect in 2- and 3-syllable words than in 1- and 4-syllable words. The interaction between word frequency and word length suggests the locus of both variables. Namely, word length affects not only prelexical processes, but also lexical processes, because the interaction between these two variables can be interpreted as evidence that both variables share a processing stage (Sternberg, 1969).

Word predictability, the third variable in this study, has been studied using different methods like eye tracking (Rayner & Well, 1996) which examined the effect of contextual constraint on the eye movements of readers who encountered predictable versus unpredictable words in a sentence. In eye tracking experiments, participants were more likely to fixate (i.e., have greater fixation probability) on words in the low-constraint than medium- or high-constraint conditions. In addition, Rayner and colleagues (2004) showed, in their eye movement experiment, that predictability at least does not interact with frequency, which suggests that these two variables influence different stages of word identification. This result is interesting because it is in contrast to the prediction that the effect of contextual information can be expected to be greater on less frequent words. Moreover, the frequency effect usually has interactions with other variables, for example, age of acquisition (Morrison & Ellis, 1995) and word length (Lee, 1999).

In sum, previous studies relevant to three main variables (i.e., word length, word frequency, and word predictability) have been reviewed. Because of the Korean writing system and orthography, internal structure properties should be considered (i.e., visual features and complexity). Together, these word length and internal structure properties will be investigated to examine what levels of sublexical units in Korean play a significant role during reading. In addition, word frequency and word predictability effects will also be investigated in the following two experiments.

Method

Cloze Task for Selecting Stimuli Sentences

In order to select a set of target words that were highly predictable from their sentence contexts so that these items would be used in a subset of stimuli (see *Stimuli* section) a self-paced reading experiment. Seventy-eight Korean undergraduate participants were presented 120 sentence fragments like *Example (2)* that terminated with a blank, and participants were instructed to write down the first word that come to their mind after reading each fragment.

Example (2)

Sentence fragment: 용욱이는/ 밤새워/ 시험 공부를 하기/ 전에/ 한잔의 _____

Pronounced: Yongwuk-i-nun/ pam-say-we/ si-hem kong-bu-lul / ha-ki/ cen-ey/ han can-uy _____

Phrasal meanings: Yong-Wook/ during overnight/ studying for exam/ before/ a cup of _____

As shown in Example (2), a main verb of Korean sentence is frequently placed at the end of the sentence (i.e., after the target word), and thereby it might be thought to provide little constraint on the target word. In contrast, the verb in an English sentence is typically located near middle of the sentence, and thereby provides relatively more constraint on the target word.

In results of this task, thirty-two responses from the cloze task that were given more than 25% of the time in sentence fragments were assigned to the *high-predictability* condition (*M* = 60%; range = 25 – 97%). The mean cloze-probability for highly predictable target words in Korean was 60%, whereas in one of study using English (Rayner et al., 2004) was 78%. English sentences can provide both semantic and syntactic constraints on a target word in a sentence, but Korean sentences mostly provide semantic, and not syntactic, constraints on a target word.

Experiment : Self-Paced Reading

For the purpose of examining how the visual, lexical, and contextual characteristics of Korean affect word identification during natural reading, word length, frequency, and predictability were manipulated among the target words. To do this, three different sets of stimuli were constructed as described in the next section.

Participants. Twenty-one native Koreans in the Pittsburgh community participated in this experiment, and twenty-five Koreans in Seoul also participated in this experiment for about $10 each. All of the participants had normal or corrected-to-normal vision.

Stimuli. A set of 108 sentences was generated, and part of this sentence set was originated from the cloze-task norms (see stimulus Set III). These stimuli consisted of three sets of 32 sentences and 12 filler sentences. More specific information about each set of sentences is given in the following:

Set I consisted of 32 sentences containing target words that varied in terms of word length (i.e., number of syllables: 1–4) and word frequency (high frequency: *Mdn* = 180 per million, range = 59–849; low frequency: *Mdn* = 1.3 per million, range = 1–26). Therefore, Set I provided the opportunity to evaluate the effect of the number of syllables as a possible unit of word length, and a possible interaction with frequency.

Set II consisted of 32 sentences containing two-syllable target words with various numbers of phonemes (*M* = 5.1; range = 3–7) and letters (*M* = 2.6; range = 2–6). The internal structure properties of the Korean words also varied in this set, but they were not directly manipulated (as was frequency in Set III) based on two properties: the various possible syllable-block (CV) combinations (Taylor, 1980), and the number of visual features (e.g., vertical lines, etc.; Nam et al., 1997). CV block combinations can have three levels of complexity based on a single letter, so the complexity of the present stimuli was based on the sum of each syllable's complexity level (*M* = 4.8; range = 3–6). The number of visual features was also based on the sum of all components in each word (*M* = 12.7; range = 7–19).

Set III consisted of 32 target sentences extracted from the cloze task and containing four types of target words: (1) high-frequency predictable words; (2) high-frequency unpredictable words; (3) low-frequency predictable words;

and (4) low-frequency unpredictable words. The frequency of the high-frequency words and low frequency words were over 53 per million (M = 149, Mdn = 114, SD = 134) and less than 9 per million (M = 2.9, Mdn = 2.3, SD = 2.5), respectively (National Academy of the Korean Language, 2002). Predictable target words were selected from the cloze task that were given more than 25% of the time (M = 60.38%, Mdn = 63%, SD = 17.64%).

Table 2: Examples of Target Stimuli of Set III.

Condition	Example Sentences
HF– P	일요일에는 미뤘던 빨래와 **청소**를 해야겠다. On Sunday, postponed, laundry, and, **cleaning**, have to.
HF – U	차가 더러워졌으니 일요일에는 반드시 **청소**를 해야겠다. Car, dirty, on Sunday, necessarily, **cleaning**, have to.
LF – P	차가 더러워졌으니 일요일에는 반드시 **세차**를 해야겠다. Car, dirty, on Sunday, necessarily, **car-wash**, have to.
LF – U	일요일에는 미뤘던 빨래와 **세차**를 해야겠다. On Sunday, postponed, laundry, and, **car-wash**, have to.

In sum, as Table 2 shows, each target word (high- or low-frequency) embedded in sentences was either predictable or unpredictable. In the unpredictable conditions, target words were selected from responses that were given less than 1% of the time. To control word length, all of the target words in Set III were two-syllable words.

Procedure. The initial display consisted of a line of dashes preserving spaces between words. The participants were instructed to press the space bar to see the first word, and then to press the bar to see each new word of the sentence; thus, whenever participants pressed the space bar, each set of dashes changed to a word (i.e., a self-paced moving window paradigm where each new word replaced a set of dashes). Participants were also instructed to read at a natural rate and to comprehend what they were reading. Before starting the experimental session, each participant read five practice sentences to become familiar with the procedure. During the experimental session, true/false comprehension questions were randomly presented after one fourth of the sentences (on average) to impose on-line comprehension of the sentence and to avoid "mechanical" pressing of the button to move forward through the text. They were then given feedback if their answer was incorrect.

Results of Experiment

Forty-one participants' data were analyzed, and all reading times for target words that were more than 3 SD's from the mean of each stimulus set were excluded from the data analyses.

Set I: Word length (number of syllables) and frequency. A stepwise regression analysis was conducted using the order as the number of syllables, corrected frequency (i.e., logarithmic frequency), and the interaction between those two variables as predictors. The R^2 statistics showed that the number of syllable did significantly predict reading times [R^2 = .832, $F(1, 30)$ = 148. 05, $p < .001$].

As predicted, the effect of word length was reliable, with the reading times for target words increasing with the number of syllables, which demonstrates the importance of word length in word identification, and the significance of the syllable as a critical processing unit in Korean. Word frequency also significantly accounted for variance [ΔR^2 = .026, $F(1, 29)$ = 5.20, $p < .05$]. Finally, interaction between the number of syllable and frequency also accounted for significant proportion of variance [ΔR^2 = .021, $F(1, 28)$ = 4.93, $p < .05$]. Figure 2 shows the result of reading times dependent on word frequency and number of syllables. In general, as far as word frequency is concerned, high-frequency words received shorter reading times than low-frequency words (M= 298.9 ms vs. 326.9 ms, respectively).

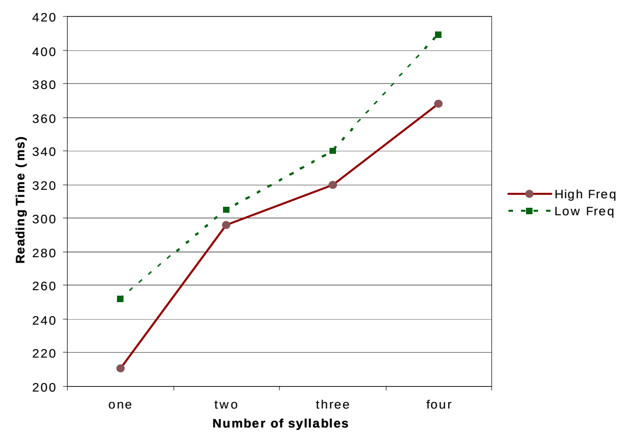

Figure 2: Reading times for target words in Set I a function of the word frequency and the number of syllables.

In addition, there was an interaction effect between frequency and length as shown in previous studies (Lee, 1999; Park, 1993; Nam et al., 1997). Interestingly, however, the pattern of the effect sizes of frequency in this experiment is different from a previous study using Korean (Park, 1993). His results showed a larger frequency effect for two- and three-syllable words compared to one- and four- syllable words.

In contrast, the present experiment showed the different pattern of interaction as Figure 2, namely, word frequency effects were greater in one- and four- syllable words than in two- and three- syllable words. For the different effect sizes of frequency depending on the number of syllables, the numerical ratio of 1–4 syllable words in the database that has used in this study was calculated as 1: 17: 14: 5 respectively. Therefore, I can conclude that the larger effect of frequency in one and four syllable words in the present experiment is because one and four syllable words are expected to be used relatively less frequently as compared to two-and three-syllable words, and it possibly made Korean native speakers' sensitivity to one-and four-syllable words much higher compared to two-and three-syllable words. It is possible, though, that latency of word identification is a function of not only the syllabic types (1-4 syllable), but also token frequency of each syllabic type.

Set II: Word length (number of letters, phonemes) and visual complexity. Because each of the target words of Set II was a two-syllable word, only the number of phonemes varied across the target words (in contrast to the target words in Set I). The visual complexity level of each word was defined using both the CV block measure and the number of visual features (see Table 1).

A stepwise regression analysis showed that only the number of visual features reliably predicted reading times ($r = .373$, $p < .05$). These results are partially consistent with results from experiments using words in isolation, such as with a lexical decision task or a naming task (Nam et al., 1997), which showed the effects of other sublexical units (i.e., phonemes, letter) as well. Thus, sublexical units' effect might be dependent on the task, for example, when native speakers of Korean read a sentence, they may be sensitive to the internal structure, but not phonemes and letters.

Set III: Word frequency and predictability. A 2 (high vs. low frequency) × 2 (predictable vs. unpredictable) ANOVA indicated reliable effects of word frequency [$F(1, 40) = 5.54$, $p < .01$] and a marginal effect of predictability [$F(1, 40) = 3.80$, $p = .058$], but no interaction ($F < .5$). A power analysis indicated that the latter was not likely to be a Type II error (power = 0.945).

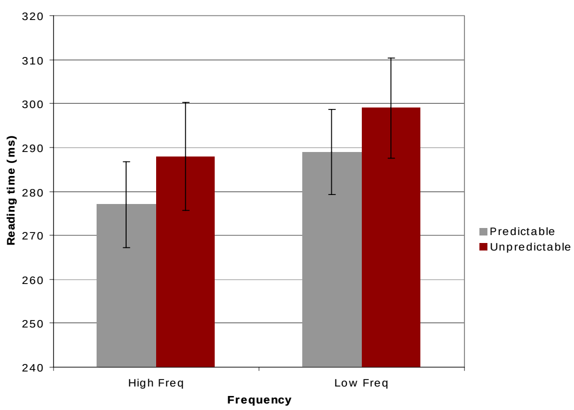

Figure 3: Reading times for target words in Set III as a function of word frequency and predictability additively. Both variables showed main effects, but no interaction.

The overall findings from Set III were thus consistent with previous eye-tracking experiments that have examined the same variables (Rayner et al., 2004). As in these experiments that used English, Korean also showed the effects of word frequency and predictability, but no interaction. Therefore, we can conclude that word frequency and predictability affect lexical access additively or that the effect different stages of lexical processing (e.g., pre-lexical vs. post-lexical processing). Note that there was a relatively weak effect of word predictability in Korean can probably be explained by the relatively lower cloze probability in this experiment.

General Discussion

The results provided some interesting findings as follows: reading times of Korean words within a sentence were affected by the number of visual features and the number of syllables, but not by number of phonemes or letters. Word frequency, representing a lexical variable, also had a significant effect on reading time for target words, as many other previous studies have shown; therefore, we can conclude that people rapidly access the meaning of frequent words as compared to infrequent words. In addition, the interaction between frequency and the number of syllables was significant. Another major finding of the present study was a sentential context effect on word identification. For the contextual effect, predictability of target words was controlled by the syntactic and semantic information shown prior to the target words. Word predictability reliably affected the reading times of target words. However, an interaction between word frequency and word predictability was not found.

One of the underlying goals of the present experiment was to suggest evidence of what reading units, among various units, have a significant role in word identification during the reading of Korean. Korean, having an alphabetic syllabary, shares properties with both English (alphabetic) and Chinese (morpho-syllabic). This property is shown in the processing unit of Korean. First, as compared to the Chinese writing system, both Korean and Chinese have a similar written form - square-shaped characters. In particular, Korean words of the CVCC type are more similar to Chinese logographs (Taylor, 1980; see Table 1). Although the internal structure variables are not directly related to word reading units, their influence has been reported. With respect to the internal structure, visual factors might play a role of in both Chinese and Korean. In Chinese, there is a complexity of character which is measured by the number of strokes (Taylor, 1980). A stroke is a dot, an L-shape, or a horizontal, vertical, or diagonal line, and there are about 20 stroke types (Wang, 1981), and it is very similar to a visual feature in Korean (Nam et al., 1997). Using Chinese, Yeh and Liu (1972) reported an adverse effect of complexity on recognition: latency for recognition was longer for complex characters (15 or more strokes) than for simple ones (10 or fewer strokes). A similar effect was found in a previous study of Korean using a lexical decision task (Nam et al., 1997) and the current experiment using self-paced reading task supports this conclusion. These results support the conclusion that both native speakers of Chinese and Korean are sensitive to this sort of visual factor, even if it is not directly related to word reading units.

Next, considering a purely alphabetic language, such as English, results from experiments showed the effect of word length, which can be measured in the number of letters (Lee, 1999) or in the number of syllables (Lovatt, Avons, & Masterson, 2000). In Korean, previous studies (Choi, 1986; Lee & Kim, 1989; Nam et al., 1997) found that the number of syllables affect the latencies for naming or lexical decision tasks. In addition, Nam and colleagues (1997) found effects based on other sublexical units, such as the number of letters or phonemes. In contrast to the experiments using naming or lexical decision tasks, the present study employed self-paced reading and only found an effect of the number of syllables. Therefore, considering both the characteristics of the Korean writing system (i.e., alphabetic syllabary) and task difference (self-paced reading), these findings suggest that the preferred processing unit of printed Korean words is the syllable, which takes the internal structure of Hangul variation into account. This conclusion is also consistent with some previous results which found that the frequency of syllable and the number of syllables that were *Kulca* (i.e., the Hangul orthographic units which corresponds to single syllable) (Yi, 1993; Lee & Kim, 1989).

In conclusion, the evidence from the present study has some implications: as an alphabetic syllabary writing system, Korean word identification is reliably affected by the number of syllables and visual features. It indicates that the status of Korean writing system, because its writing system shares the properties of neighbor writing system. Therefore, both visual features as a logographic property (i.e., strokes in Chinese) and syllables as an alphabetic property have influence on Korean word identification. The reason why there are no effects of letters and phonemes on reading times cannot be currently determined, now, but the task situation, word in text, can imply that the sublexical units' role could be reduced in that situation. There was no effect of the number of letters or phonemes in this experiment. Word frequency is a strong factor for Korean word identification regardless of task differences. Word predictability also has a significant role in this process, even if its cloze probability was lower (by weak syntactic constraints) than English study. This may reflect a broad difference between languages: Korean (or Chinese) is more topic prominent language rather than English which is more syntax prominent language (Li, 1976).

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