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Syllable Transposition Effects in Korean Word Recognition

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Abstract Research on the impact of letter transpositions in visual word recognition has yielded important clues about the nature of orthographic representations. This study investigated the impact of syllable transpositions on the recognition of Korean multisyllabic words. Results showed that rejection latencies in visual lexical decision for syllable-transposed Korean nonwords were delayed as compared with matched Korean nonwords without syllable transpositions. These findings bolster the case that the syllable provides an important functional unit in Korean word recognition, and suggest a degree of position invariance in syllable representations.

Keywords Transposition effect · Syllable · Korean · Lexical decision task

Introduction

One key question in research on visual word recognition concerns the nature of orthographic coding in alphabetic writing systems. There is broad agreement that orthographic repre-

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sentations must contain information about both letter identity and letter position (otherwise, we could not distinguish anagram stimuli such as POT, OPT and TOP), but there is a lack of consensus as to how this is achieved. One phenomenon that has been used to investigate the precision of letter position coding is the transposition effect. Research using English and other Indo-European languages has shown that letter strings with internal transpositions (e.g. JUGDE) are perceived as being very similar to their base words (e.g. JUDGE), indicating a degree of flexibility or uncertainty in letter position coding (e.g. Frankish and Turner 2007; Perea and Lupker 2004; Schoonbaert and Grainger 2004).

While letter transposition effects have been observed repeatedly in Indo-European languages, they do not appear to be a universal phenomenon. For example, studies by Lee and Taft (2009, 2011) appeared to suggest that letter transposition effects are not observed in Korean word recognition (see also Velan and Frost 2007, 2011 for studies on Hebrew). Specifically, Lee and Taft (2009) created stimuli that had transpositions across the 1st and 2nd syllable of multisyllabic words in both Korean and English (e.g., 문장, napkin). These transpositions involved swapping the onsets, the codas, or the codas for onsets across the syllable boundary (e.g., 문장 ->준망 [onset exchange condition]; napkin -> kapnin). They measured the time taken for participants to reject these new stimuli as nonwords in visual lexical decision. Results showed that while transposed letter stimuli proved difficult for the English participants to reject as nonwords (compared to control nonwords without transpositions), this latency cost was considerably reduced for the Korean stimuli. In a subsequent study using the same lexical decision technique, they showed no letter transposition effect when the onset and coda of a Korean word were exchanged within a syllable (e.g., 문장 ->눔장) (Lee and Taft 2011). Both of these studies indicate that Korean readers may be using quite precise orthographic coding as compared to the English readers.

The work reported in this article moves on from the orthographic coding of letters to the orthographic coding of another sublexical unit: the syllable. The Korean writing system is interesting insofar as it is syllabic as well as alphabetic. To be specific, it is an alphabetic orthography in the sense that each letter usually corresponds to a phoneme, and it is also syllabic because there is an actual physical gap between syllables (e.g., the word 음절 has two syllables with three letters in each syllable). In line with its status in the writing system, Simpson and Kang (2004) observed that performance in reading aloud Korean multisyllabic words is affected by manipulations of the frequency of syllables. This result suggests that representations of the syllable may play a functional role in Korean word recognition. Similar syllabic effects have also been observed in Spanish and French (Carreiras et al. 1993; Conard and Jacobs 2004; Mathey and Zagar 2002; Perea and Carreiras 1998). In the light of the potential importance of the syllable for Korean word recognition, it is of interest to consider the precision with which it is coded.

The approach to this question taken in our work was to investigate whether there is a syllable transposition effect on Korean word recognition. Only a few such studies have been undertaken, and they have yielded mixed results. Perea and Carreiras (2006) measured rejection latencies in lexical decision for nonwords with syllable transpositions (e.g. PRIVEMARA from the word PRIMAVERA) against control nonwords with transpositions of adjacent bigrams that did not form a syllable (e.g. PRIMERAVA). They also designed nonword controls for both conditions in which the critical letters were replaced rather than transposed. Results showed that both the syllable-transposed and the bigram-transposed conditions yielded longer rejection latencies than the replaced-letter controls, but that there was no difference between the syllable-transposed and bigram-transposed conditions. This result

led Perea and Carreiras (2006) to conclude that the syllable is not represented at an *orthographic* level in Spanish. In contrast, a study by Taft et al. (1999) did report a syllable transposition effect in Chinese. They found that rejection latencies for transposed nonwords such as 福幸 (from the source word 幸福 meaning happiness) were longer than those for control nonwords without syllable transpositions. In contrast to the results of Perea and Carreiras (2006), this result suggests that lexical representations in can be activated by stimuli in which the syllables are transposed. However, one important difference between the work of Perea and Carreiras (2006) and Taft et al. (1999) was that in the case of Chinese, the individual syllables had meanings, whereas in the case of Spanish, the individual syllables were meaningless. For example, the transposed nonword 福幸 (from the source word 幸福 meaning happiness) has the meaning of "fortune" for the first syllable and "lucky" for the second syllable. Thus, it could be that the meanings of each syllable are computed, and it is this similarity in meaning that activates the base word. The tentative conclusion is that if a transposed unit is a morpheme or looks like a morpheme, it can elicit a syllable transposition effect.

In line with this hypothesis, Crepaldi et al. (2013) recently reported a morpheme transposition effect by showing that nonwords comprising transposed compounds (e.g., stringham) were rejected more slowly in lexical decision than that matched nonwords that were not transposed compounds (e.g., stringtoe). This study further showed that having the morphological form is sufficient to elicit the confusion, since opaque morpheme transpositions (i.e., stringham versus stringtoe) elicited similar costs on rejection latency as compared to transparent morpheme transpositions (e.g., dogsheep versus dogpaint).

The current study seeks to assess whether there is a syllable transposition effect for Korean multisyllabic words. We investigated syllable transpositions within two kinds of words, 'normal' Korean words and 'foreign' Korean words. 'Foreign' Korean words are phonological transcriptions of borrowed English words. In contrast to 'normal' Korean words, which frequently have an internal morphological structure that corresponds to the syllable (making these words similar to those used in Crepaldi et al. 2013), this is never the case for 'foreign' Korean words. This means that the syllables within 'foreign' Korean words are more comparable to stimuli used in Perea and Carreiras (2006) than are 'normal' Korean words. Our analyses will focus on (a) whether there is a syllable transposition effect against control nonwords without syllable transpositions and (b) whether this effect arises for both 'normal' and 'foreign' Korean words. If the effect arises for both classes of Korean words, then we can infer that the effect does not arise as a result of morphemic or semantic similarity across the transposed nonword and the base word (i.e. because syllables of 'foreign' Korean words have no morphemic or semantic status). In contrast, if the effect arises only for 'normal' Korean words, then we could infer that the effect has a morphemic or semantic locus.

The Experiment

The experiment involved participants making lexical decisions to visually-presented four-syllable Korean words. Our key question was whether rejection latencies would be longer for nonwords in which the middle two syllables were transposed than for control nonwords that did not have a syllable transposition. Further, in order to home in on the locus of any such transposition effect, we employed both typical Korean words in which syllables also contain morphemic as well as orthographic/phonological information, and foreign Korean words in which syllables carry only orthographic/phonological information.

Method

Participants

Fifty students enrolled in an Introductory Psychology class at Sogang University participated in the experiment. They all had normal or corrected-to-normal vision, and earned a course credit for their participation.

Materials

Thirty-six four-syllable base words were selected from the Korean Word Database (2001). Half of these were typical Korean words (e.g.,1 해수욕장; translation *beach*), and half were Korean words borrowed from a foreign language, usually English (e.g., 아이디어; translation *idea*). While syllables in typical Korean words often carry morphological information (and this was the case for approximately 44 % of our stimuli), this is never the case for foreign words which are simple phonological transcriptions.

We transposed the middle two syllables of each of these 72 words to make the syllable-transposed nonwords (i.e., 해욕수장 for 해수욕장). Control nonwords were created by substituting the consonant of the third syllable of the transposed syllables (e.g., 해욕주장 for 해욕수장). Syllable-transposed nonwords from typical Korean words and those from Korean foreign nonwords were matched on base-word frequency (transposed M = 186.61, sd = 263.93; control M = 192.11, sd = 226.42; Korean Word Database 2001). In addition, syllable transposed nonwords from typical Korean words and those from Korean foreign words were matched with their control nonwords in terms of Coltheart's N (Coltheart et al. 1977; both Ms = 0.056 for Korean typical words and their controls, both Ms = 0 for Korean Foreign words and their controls).

Thirty-six four-syllable Korean words were selected as fillers for the 'yes' response of the lexical decision task. These filler stimuli were a mix of typical Korean words and foreign Korean words that are routinely used in daily life.

Nonword stimuli were split into two lists in order to avoid participants seeing similar items across the experiment. Each list therefore had 72 items, half words and the other half nonwords. For the nonwords, 18 had syllable transpositions while the other 18 were control nonwords. Half of these stimuli were based on 'typical' Korean words and half were based on 'foreign' Korean words. Twenty practice items were also included in each list.

Procedure

Participants were instructed to decide whether letter strings appearing at the center of a 586 PC computer LCD screen were words or nonwords. The refresh rate of the Pentium monitor was 60Hz making the refresh rate (one tick) equal to 16.67 ms. A sequence of four visual events comprised each cycle, and the stimuli were in the same location at the center of the screen. There were (1) five hash marks for 501 ms, followed by (2) the target item for 2000 ms. The stimulus presentation and duration were controlled by DMASTER software (developed at Monash University and University of Arizona by K. I. Forster and Forster 2002).

Results

Response latencies <200 ms and more than 1600 ms were discarded as outliers. Trials in which an incorrect response was made were also excluded from the reaction time (RT)

Table 1 Mean rejection latencies and % error rates (ER) based on the by-participants analysis of the nonwords in the experiment

Transposed condition	RT (ms)	ER (%)
Typical Korean		
Syllable-transposed	831	11.1
Control	793	6.4
TL effect	38	4.7
Foreign Korean		
Syllable-transposed	810	8.9
Control	760	2.7
TL effect	50	6.2

analysis. Rejection latencies and error rates for the syllable-transposed and control conditions are presented in Table 1.

Rejection latencies and error rates were analyzed via an analysis of variance (ANOVA) with transposition (syllable-transposed versus control) and word type (typical Korean versus foreign Korean) as repeated factors and counterbalancing list as an unrepeated factor. Only effects involving transposition and word type are reported.

Analyses of the latency data revealed a main effect of transposition condition (F1[1, 49]=9.7, $p < .01$, $\eta^2 = .15$, F2[1,17]=7.1, $p < .05$, $\eta^2 = .25$), indicating that syllable-transposed stimuli were responded to more slowly than control stimuli. There was also a main effect of word type (F1[1,49]=6.6, $p < .05$, $\eta^2 = .08$, F2[1,17]=5.4, $p < .05$, $\eta^2 = .16$), indicating that typical Korean words were responded to more slowly than foreign Korean words. There was no interaction between transposition condition and word type ($F < 1$), indicating that syllable transpositions elicit confusion for both types of Korean words. The error analysis revealed a main effect of transposition condition (F1[1, 49]=15.4, $p < .01$, $\eta^2 = .21$, F2[1,17]= 7.8, $p < .05$, $\eta^2 = .26$), with higher error rates to syllable-transposed stimuli than to control stimuli. There was also a main effect of word type in the subject analysis (F1[1, 49]=6.5, $p < .05$ $\eta^2 = .07$) but not in the item analysis (F2[1,17]= 2.1, $p > .05$). The interaction between these two variables was not statistically significant (F1 <1, F2[1,17]=1.6, $p > .05$).

The results of our main analysis indicated no difference in the cost of transposition between typical Korean words and foreign Korean words. However, it could be that a difference emerges when we consider only those 44 % of our typical Korean stimuli in which the syllables carry morphemic information. In order to investigate this possibility, we conducted a sub-analysis that excluded typical Korean stimuli in which syllables were not also morphemes. Only the by-subjects analysis was conducted given the small number of stimuli in the typical condition (8 items). The latency data revealed a main effect of transposition condition (F[1,49]=4.5, $p < .05$, $\eta^2 = .06$) and a main effect of word type ([1, 49]=11.9, $p < .01$, $\eta^2 = .18$), with no interaction between these factors ($F < 1$). These analyses indicate that syllable-transposed stimuli were responded to more slowly than control stimuli, irrespective of whether they were typical (morphemically-structured) Korean words or foreign Korean words. For the error analysis, while there was an effect of word type in the sub-analysis, (1[1,49]=4.7, $p < .05$, $n^2 = .06$), there was neither an effect of transposition condition (F[1, 49]=3.7, $p > .05$) nor an interaction between these variables, (F[1,49]=1.9, $p > .05$). Overall, then, there was no evidence from the sub-analysis that the robust effect of syllable transposition observed in the main analysis differed across typical Korean words and foreign Korean words.

Discussion

This study was conducted to investigate the syllable transposition effect for Korean words. Our experiment found significant syllable transposition effects for both typical Korean words and Korean words phonologically transcribed from foreign words. These results allow us to infer that like the study of Chinese word recognition reported by Taft et al. (1999), syllable transposition effects arise in Korean word recognition. However, our data allow us to go beyond the work of Taft et al. (1999) in allowing us to infer that the locus of these syllable transposition effects in Korean is not morphemic or semantic. We can therefore conclude that the syllable is represented in Korean word recognition, and that this representation is characterized by position uncertainty.

These results provide an interesting contrast to the results of Lee and Taft (2009, 2011), who found no *letter* transposition effect in Korean word recognition. The results of Lee and Taft (2009, 2011) therefore suggest very precise coding of letter position within orthographic representations. Why would letter position be coded precisely while syllable position is coded loosely in Korean word recognition? The work of Frost (2012) suggests that key characteristics of the writing system shape the nature of orthographic coding. When a writing system yields a very dense orthographic space (i.e. many anagram stimuli), as in Hebrew, then letter position must be coded very precisely. In this respect, it may be critical to note that our analysis of the Korean Word Database (2001) suggests that 21 % of Korean monosyllables are anagrams (i.e. transpositions of the letters corresponding to onset and coda yield another existing word). By contrast, anagrams based on the syllable transposition of four syllable words are very rare.

Our experiment allowed us to rule out a morphemic or semantic locus for the syllable transposition effect, and suggested that the syllable is represented as a functional unit in Korean visual word recognition. One interesting question is whether that syllabic representation is orthographic, phonological, or both. Visual lexical decision is typically thought to probe orthographic levels of representation (e.g. Coltheart 2004), and given the physical demarcation between syllables, it is not unlikely that the syllable is represented orthographically in Korean. However, it is also possible that the syllable is represented phonologically, and that Korean readers make their lexical decisions (at least in part) on the basis of phonological information. Substantial research already shows strong phonological effects in Korean reading (Kim and Lee 2003; Lee et al. 2003; Lee and Kwon 2007). Indeed, the Korean writing system was invented by King Sejong around 1400 A.D. with the explicit principle of conveying phonological information within the shapes of letters. For example, as an orthographic stroke increases, the number of phonological features that a phoneme has also increases (“ㄴ[n]” -> “ㄷ[d]” -> “ㅌ[t]”; “ㄱ[g]” -> “ㅋ[k]”; ㅅ[s] -> ㅈ[z]). Further, Korean is highly transparent in terms of the mapping between spelling and sound, making it possible to compute phonological information very rapidly during visual word recognition. Thus, while our work has shown that Korean readers access a position-invariant syllabic representation, further work will need to determine whether this representation is orthographic, phonological, or both.

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