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Investigating Transposed Letter Effects in Korean using Masked Priming

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Abstract

Typographical errors caused by transposing two letters in a word (e.g., *jugde* for *JUDGE*) are often readily misperceived as the words themselves. This phenomenon, known as the transposed letter (TL) effect, has been used widely in studying letter position coding in reading. Previous research by Lee and Taft (2009) found no TL effects in Korean, a nonlinear script, causing Lee and Taft to argue that the processing of letter position information varies as a function of the orthographic structure of a language. In particular, Lee and Taft suggested that, given the orthographic structure of Korean syllables, TL nonwords should not activate their base words and, therefore, no TL effects should exist in Korean. The purpose of the present research was to evaluate this claim using the masked priming, lexical decision task (LDT), a more conventional method for evaluating automatic processing than the simple, unprimed LDT used by Lee and Taft. TL primes were generated by transposing letters between syllables. Mirroring the manipulations used by Lee and Taft, there were three types of TL primes: onset1-onset2 transpositions, coda1-coda2 transpositions, and coda1-onset2 transpositions. Replacement primes created by replacing the transposed letters in TL primes with two other letters were used as control primes for each condition. As Lee and Taft predicted, no facilitation effects emerged, however, there were significant inhibition effects following TL primes, effects that Lee and Taft's analysis cannot explain.

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Give thanks to the Lord, for He is good; His love endures forever. – 1 Chronicles 16:34

Investigating Transposed Letter Effects in Korean using Masked Priming

Successful reading requires people to recognize the visual representation of words by identifying both the letters and how those letters are ordered. Accurate information of letter positions in reading a word is crucial in distinguishing, for example, *garden* from *danger*, and recognizing that *ngedar* is not a word. Yet, the process of coding letter positions seems to have some tolerance for incorrect letter orderings. For instance, most people have little difficulty understanding the following sentence: *The jugde found the defendnat gulity of murdre*. Essentially, when a nonword is created by switching positions of two adjacent letters in a word, it is hard to distinguish that nonword from the base word. The existence of this phenomenon, and its implications, has become one of the major research topics in reading research over the past decades. Experimental demonstrations in the lab that nonwords formed by transposing letters do strongly resemble their base word have become known as transposed letter (TL) effects.

Previous research reported the presence of TL effects in many different languages, for example, English (e.g., Perea & Lupker, 2003), Spanish (e.g., Perea & Lupker, 2004) and Japanese (e.g., Witzel, Qiao & Forster, 2011). These languages share a common characteristic, they are linear scripts. Further, words can start with either a vowel (e.g., *apple*) or a consonant (e.g., *banana*; in case of Japanese, a vowel syllable and a consonant-vowel syllable, respectively). Therefore, virtually any ordering of characters in a word is theoretically legitimate and the position of a letter in a word is a relative thing, that is, it is relative to the other letters in that word. As a result, there is the potential for ambiguity in terms of what letters are in what letter positions, and because of this ambiguity, it makes sense that TL effects would be readily observed in these languages. In fact, some studies revealed that TL effects are not limited to adjacent letter transpositions (e.g., *caniso* for *CASINO*; Perea & Lupker, 2004), and that even dramatic transpositions (e.g., *ocpmture* for *COMPUTER*) can produce TL effects (Lupker & Davis, 2009).

Theories of Letter Position Coding

Davis and Bowers (2006) compared five theories of letter position coding: slot-coding, Wickelcoding, discrete and continuous open-bigram (OB) coding, and spatial coding, in an attempt to find the best explanation for the TL phenomena. Slot-coding is position-specific, assuming that letter identity is easily and rapidly associated with letter position when reading a word. For example, consider the words *cat* and *act*. The letter *c* is slotted directly into the first letter position in the word *cat*, whereas it is slotted into the second letter position in the word *act*. According to the slot-coding theory, the two *c*s would not be processed as the same letter because they are in different positions. Wickelcoding theory assumes that letter identities are encoded with the information about how a letter is positioned in relation to other letters (e.g., the letter *c* in the word *track* has *a* on its left and *k* on its right). Both slot-coding and Wickelcoding schemes cannot explain TL effects. In slot-coding, a nonword created by a letter transposition (e.g., *jugde* for *JUDGE*) and a nonword created by a two letter substitutions (e.g., *jupte*) should be equally similar to their base word and have the same effect on base word processing. This is not the case. Wickelcoding predicts that *jugde* and *JUDGE* have totally different features because each letter's relative-position information is changed due to the transposition, a prediction that is also not consistent with the data.

In OB coding, a word is coded as a set of ordered letter pairs and these pairs activate the mental representation of the word (Davis & Bower, 2006). In discrete OB coding, the word *clam* activates the letter pairs *cl, ca, cm, la, lm* and *am*. Continuous OB coding would predict activation of only adjacent letter pairs (*cl, la,* and *am*). The two versions of OB coding can account for TL effects. The number of shared letter pairs (i.e., bigrams) between a transposed letter nonword and its base word is greater than between a replacement letter nonword and its base word. Therefore, transposed nonwords are expected to be more similar to their base word than replacement letter nonwords.

Spatial coding assumes that each letter is coded by a letter node, and these nodes are activated independently of letter position context (Davis & Bower, 2006). For example, both *top* and *opt* would activate a node that codes for the letter *t*, regardless of how the letter is positioned. It is also assumed that letter positions have different levels of activation and that letter-coding nodes would be activated to different degrees, depending on the letter's positions. The first letter position of a word has the highest level of activation, the second letter position has the next highest activation, and so on. So, *top* and *opt* would create different patterns of activation, allowing the two words to be distinguished. How spatial coding explains TL effect is as follows: because the same letters are activated in the transposed letter stimulus and the base word when letters are transposed, the activity patterns created by the two stimuli would differ slightly. More importantly, however, the same set of letters are being activated by both stimuli, making the two stimuli quite similar to one another orthographically. In contrast, the activity level pattern of the base word would be very different from the pattern of a replacement letter nonword (i.e., one in which the transposed letters have been replaced by other letters), meaning that these two stimuli would not be very similar orthographically. Thus, spatial coding would provide an explanation for TL effects.

Although both spatial coding and OB coding can account for TL effects, research directly contrasting these theories has often yielded inconclusive results, causing proponents of the two theories to argue for them on the basis of other considerations. Researchers who support OB coding argued that the OB coding scheme involves a direct pathway between the letter pair units and word representations, while the complex neural mechanism of spatial coding is "computationally much more costly" (Whitney, Bertrand & Grainger, 2012, p.144). Other researchers criticized OB coding's apparent inability to explain priming effects in a number of situations (e.g., reversed-order bigrams; Kinoshita & Norris, 2013) which the spatial coding scheme is able to accommodate (Davis & Bowers, 2006).

Development of Question for the Present Research

Despite the overwhelming number of TL effects in the literature, two language systems have failed to show TL effects: Semitic languages (Arabic; Perea, abu Mallouh, & Carreiras, 2010; Hebrew; Kinoshita, Norris, & Siegelman, 2012) and Korean using Hangul script (Lee & Taft, 2009, 2011). The present research was designed to re-examine TL effects in Korean in order to determine whether Lee and Taft's explanation of the lack of TL effects in Korean is correct.

Most research investigating TL effects has involved the masked priming lexical decision task. In this task a prime is presented briefly prior to a target to which people must make a lexical (i.e., word-nonword) decision. A TL effect is observed if a TL prime (e.g., *jugde*) provides more facilitation of target (i.e., *JUDGE*) processing than a replacement letter prime (e.g., *jupte*). Research in Semitic languages has not shown these types of effects. Semitic languages such as Hebrew and Arabic are similar to Indo-European languages with respect to having alphabetic orthographies. However, a critical difference between Semitic languages and Indo-European languages lies in the importance of the morphological structure of the words, which has been argued to be the reason TL effects do not appear in these languages. In Hebrew and Arabic, words have morphological roots (usually a string of three consonants) which determine the word's meaning and word patterns (additional letters that are vowels and some consonants) that are added to the root letters to indicate the word's grammatical function (Perea, abu Mallouh, & Carreiras, 2010). Transposing root letters produces different roots and hence, different words, rather than producing just a misspelling of the target word. As a result, TL primes in these languages, actually being other words, provide little, if any, activation of their base words.

In addition, Lee and Taft (2009, 2011) did not find TL effects in Korean. They argued that the reason was that onset-vowel-coda syllable structure of Korean characters eliminates any ambiguity in letter positions. Lee and Taft concluded that this structural difference also makes the process of letter position coding is quite different in Korean than in other languages. Before accepting these claims, however, one must explore alternative explanations and limitations of their research.

Background Information

Korean Hangul script. The Korean alphabet, called Hangul, has 14 simple consonants and 10 simple vowels as well as 16 complex consonants and 11 complex vowels. All Korean letters are shown in Table 1a. Hangul characters, however, are syllables, usually consisting of one consonant and one vowel, or two consonants and a vowel. Table 1b shows which letters can go into which positions within a syllable.

Table 1a.

The Korean alphabet consonants and vowels.

	Consonants	Vowel
Simple	ㄱ, ㄴ, ㄷ, ㄹ, ㅁ, ㅂ, ㅅ, ㅇ, ㅈ, ㅊ, ㅋ, ㅌ, ㅍ, ㅎ	ㅏ, ㅑ, ㅓ, ㅕ, ㅗ, ㅛ, ㅜ, ㅠ, ㅡ, ㅣ
Complex	ㄲ, ㄸ, ㅃ, ㅆ ㅉ, ㄳ, ㄵ, ㄶ, ㄺ, ㄻ, ㄼ, ㄽ, ㄿ, ㅀ, ㄾ, ㅄ	ㅐ, ㅒ, ㅔ, ㅖ, ㅘ, ㅙ, ㅚ, ㅝ, ㅞ, ㅟ, ㅢ

Note: the Korean alphabet is composed of 14 simple consonants, 16 complex consonants, 10 simple vowels and 11 complex vowels.

Table 1b.

The Korean letters that can go into each subsyllabic position

	Onset	Vowel	Coda
Simple	ㄱ, ㄴ, ㄷ, ㄹ, ㅁ, ㅂ, ㅅ, ㅇ, ㅈ, ㅊ, ㅋ, ㅌ, ㅍ, ㅎ	ㅏ, ㅑ, ㅓ, ㅕ, ㅗ, ㅛ, ㅜ, ㅠ, ㅡ, ㅣ	ㄱ, ㄴ, ㄷ, ㄹ, ㅁ, ㅂ, ㅅ, ㅇ, ㅈ, ㅊ, ㅋ, ㅌ, ㅍ, ㅎ
Complex	ㄲ, ㄸ, ㅃ, ㅆ, ㅉ	ㅐ, ㅒ, ㅔ, ㅖ, ㅘ, ㅙ, ㅚ, ㅝ, ㅞ, ㅟ, ㅢ	ㄲ, ㄳ, ㄵ, ㄶ, ㄺ, ㄻ, ㄼ, ㄽ, ㄿ, ㅀ, ㄾ, ㅄ, ㅆ

Note: Simple consonants can go into either the onset position or the coda position. Not every complex consonant can go into either the onset position or the coda position.

Equally important, Hangul has a unique orthographic structure in that there are specific letter positions for the consonants and vowels in Korean characters (see Figures 1, 2, and 3 for visual representations).

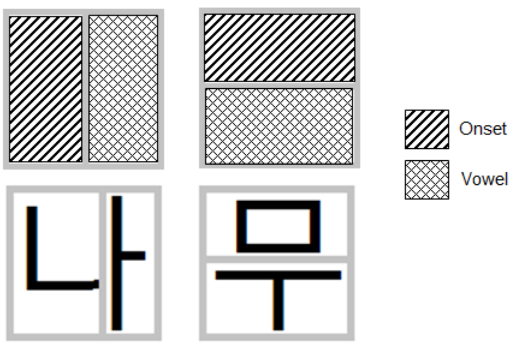

Figure 1. Syllables with an onset and a vowel.

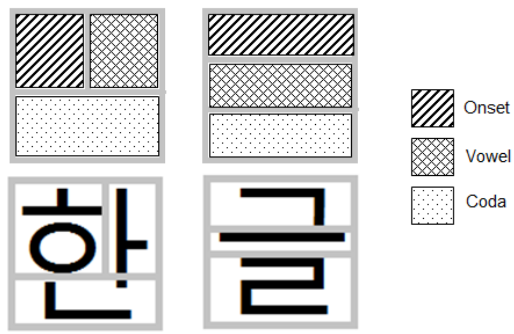

Figure 2. Syllables with an onset, a vowel, and a coda.

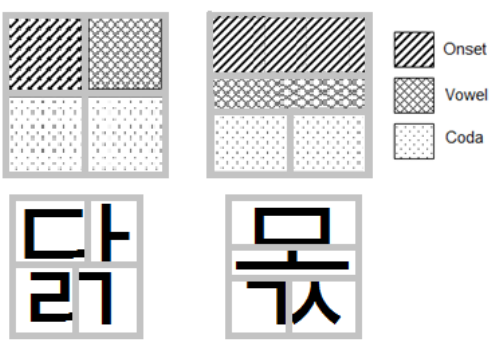

Figure 3. Syllables with two letters in the coda.

In a square-like character (i.e., a syllable), consonants preceding a vowel (i.e., onsets) always appear in the top or top-left position. Vowels are written to the right of or below onsets. Consonants following a vowel (i.e., codas) are placed at the bottom of the syllabic square. Korean syllables always begin with consonants and never with vowels; even when the onset is silent, a consonant representing silence (i.e. ㅇ) is placed at the onset position. This physical structure of onset-vowel-coda pattern is thought to reduce the letter position ambiguity, which is common in linear alphabetic scripts such as English.

Word Recognition Research in Korean. There is accumulating empirical evidence that the process of word recognition in Korean is different from other languages. Kim and Davis (2002) examined the influence of phonology in visual word recognition in Korean, using a masked priming naming task and a masked priming lexical decision task (LDT). There was no orthographic priming for monosyllabic words in Korean in either the naming task or the LDT, suggesting that one may not actually get orthographic priming in Korean. Further, Lee, Lee and Kim (2010) conducted a simple presentation LDT (i.e., no priming was involved) to show that the units of lexical processing in Korean word recognition are the antibody (i.e., onset + vowel) plus the coda, rather than the onset plus the body (i.e., vowel + coda), which are the lexical processing units that seem more important when reading English words. Lee and Choi (2009) also supported the antibody-coda lexical processing unit theory using a masked priming LDT. Based on this work, Park and Lim (2014) built a computational model to explain the differences found between word recognition in Korean and word recognition in other languages such as English. Park and Lim's model matched the behavioural data closely and supported the ideas that Lee and colleagues (2009; 2010) proposed.

Transposed Letter Effects in Korean. Lee and Taft (2009) found TL effects in English but not in Korean. Words and nonwords that are 6-letters long and bisyllabic were presented as stimuli. Transposed letter nonwords were created by swapping one letter from a syllable with one letter from the other syllable. Transpositions occurred between: the first and the fourth letters (i.e., the onset-onset swap), the third and the sixth letters (i.e., the coda-coda swap), and the third and the fourth letters (i.e. the coda-onset swap). Using a simple presentation LDT, those researchers showed that there were significant TL effects in all conditions in English (i.e., TL nonwords took longer to classify as nonwords), but little to no TL effect in Korean. Lee and Taft suggested that the difference in orthographic structure between English and Korean was the reason for the absence of TL effects in Korean. Because letters in Korean are associated with set physical positions (i.e., onset-vowel-coda positions), it is not difficult for a Korean reader to rapidly assign letters into their appropriate slots. On the other hand, letter assignment into physical positions in English is much more complicated. It was therefore suggested that the clarity of letter position information provided by the unique physical structure of Korean preventsTL effects.

In a follow-up study in 2011, Lee and Taft investigated TL effects by transposing letters within syllables. In their first experiment, Lee and Taft used 6-letter disyllabic words and nonwords that were similar to the stimuli used in 2009. All letter transpositions took place between the onset and the coda of a syllable. Only one of the two syllables contained a letter transposition. Lee and Taft failed to observe a TL effect in a single presentation LDT, although it was noted that it was easier to determine that the stimulus was a nonword when the transposition was in the first syllable than in the second syllable.

In their second experiment, Lee and Taft (2011) examined TL effects using monosyllabic or disyllabic words that had one syllable with two consonants in the coda position. Letters were transposed between the onset and the first consonant of the coda, or between the two coda consonants. The results revealed a significant TL effect, however, only in the coda-coda within-syllable transposition condition. Lee and Taft argued that, although there is no ambiguity that a consonant at the bottom of a syllable serves as a coda, there is some ambiguity in assigning the consonants to the first versus the second coda position. Therefore TL effects can arise in Korean but only when the transposed letters have the same subsyllabic function.

The Choice of Methodology

In evaluating Lee and Taft's (2009, 2011) arguments, one must first consider their experimental methodology. Among many methodologies used for investigating TL effects, only two will be discussed here: the single-presentation lexical decision task (SPLDT) that Lee and Taft used and lexical decision task with masked priming. In SPLDT, participants are asked to perform a standard lexical decision task (i.e., to determine whether or not a letter string on a computer screen is a word). The target stays on the screen until the participant responds by pressing a button corresponding to their decision. Results typically show that people take more time to say "no" to TL nonwords than to control (i.e., replacement letter) nonwords. The reason is that because TL nonwords consist of the same letters as their base words, the base word's mental representation would be partially activated. The result is an inhibition or delay in people deciding, for example, that *nakpin* is a nonword.

In experiments using the lexical decision task with masked priming, each trial begins with the brief presentation of a mask (e.g., ######). The mask is replaced by a prime, presented too briefly for participants to become aware of it (e.g., 40-60 ms). Then, a target appears on the screen until a response is given. The TL effect in this situation is facilitory, rather than inhibitory, because latencies are shorter following TL primes than following control (replacement letter) primes. The explanation is that the subconsciously perceived TL nonword prime activates the mental representation of the base word, making it easier to say "yes" to the target word.

Although Lee and Taft's (2009, 2011) SPLDT methodology is one of the methods used in investigating TL effects, it has not been the preferred paradigm in most studies in the field. The majority of research has used masked priming along with a lexical decision task. Masked priming has an advantage over SPLDT because it more directly reflects processes that occur early in word recognition (Forster, Mohan, & Hector, 2013, p. 6). Masked priming involves subliminal perception of primes, thus it taps into automatic processing better than SPLDT. If Lee and Taft's results were replicated using masked priming, confidence in their claim would be strengthened. If not, it would suggest that TL effects arise in Korean just as they do in most languages and that the SPLDT was an insensitive method for studying TL effects in Korean.

Issues with the Stimuli

In Experiment 2 of Lee and Taft's study (2009), very weak TL effects were observed in two of their three Korean TL conditions. That fact suggests that TL effects may exist in Korean but Lee and Taft did not have enough stimuli to produce a significant effect. Only 14 words were used to generate TL nonwords and control nonwords. Considering the typical number of words used in this type of research is usually at least 60 and often as many as 100 (e.g., Perea & Lupker, 2004; Lupker, Perea, & Davis, 2008; Perea & Acha, 2009; Perea, abu Mallouh, & Carreiras, 2010; Witzel, Qiao, & Forster, 2011), it seems reasonable to raise questions about the experimental power in Lee and Taft's experiments. Thus, the present experiment incorporated more stimuli in our investigation of TL effects in Korean.

In summary, the goal of this research was to re-investigate TL effects in Korean by using the more standard technique of a masked priming LDT with a larger stimulus set. The presence of a TL effect would suggest that any orthographic cues that constrain letter position in Korean become relevant in processing later than the point at which letter identification takes place.

Hence, it would suggest that early orthographic processes in Korean are similar to those in most languages (i.e., they can lead to ambiguity in position coding). The absence of a TL effect would indicate that orthographic position cues become relevant very early during word recognition and that they play a crucial role in constraining letter position coding during word recognition in Korean.

Method

Participants

Undergraduate students from the University of Western Ontario and volunteers from local Korean communities took part in the experiment. There were thirty-four participants, composed of 18 females and 17 males ranging from age 18 to 27 (M = 20.62, SD = 2.56). Only participants who met the following criteria were eligible to participate: (1) between the ages of 18 and 60, (2) have lived in Korea for a minimum of 10 years, (3) frequently speak Korean on a daily basis, and (4) have normal or corrected-to-normal vision. Participants also had to successfully complete two types of reading tasks in Korean. One reading task involved a question from the advanced level of the official Korean Proficiency Test. To answer this question correctly requires the ability to understand the context and apply knowledge of an idiom. The other reading task involved the participants reading aloud to the experimenter six Korean words that were hard to pronounce for non-native Korean speakers (see Language experience questionnaire in Materials for details). Those undergraduates who are taking an introductory psychology course received course credit for participating in the experiment. Participants from Korean communities did not receive formal compensation for their participation.

Materials

Targets. The word targets were 90 disyllabic, six-letter Korean words. Their mean word frequency (per 3 million words) was 71.6 (range: 1-637; Kim, 2005). An additional set of 90 disyllabic six-letter Korean nonwords were selected as targets for the nonword trials. These nonword targets were created by replacing either the onset or the coda of the second syllable of real Korean words. None of the word targets were used to create the nonword targets.

Primes. To match Lee and Taft's (2009) manipulation, six prime conditions were created for each target (both word and nonword): (1) transposition of the onsets (the first consonants of each syllable; the O-O TL condition), (2) transposition of the codas (the second consonants of each syllable; the C-C TL condition), (3) transposition of the coda of the first syllable and the onset of the second syllable (the C-O TL condition), (4) replacement of the onsets with other consonants (the O-O RL condition), (5) replacement of the codas with other consonants (the C-C RL condition) and (6) replacement of the coda of the first syllable and the onset of the second syllable (the C-O RL condition). For the complete list of targets and primes used in this study, see Appendix D. Lexical decision tasks in Indo-European languages such as English present primes in lower-case and targets in upper-case. Because the Korean script does not have different letter cases, the primes were presented in a smaller font size than the font size of the targets (prime font size = 50 pt; target font size = 72 pt).

Lists. To achieve counterbalancing, six lists of materials were formed by dividing word and nonword targets into six sets of size 15. Each target appeared only once in each list, with its priming condition alternating across the lists (see Figure 3 for a visual representation). Thus, there were 180 targets and 180 corresponding primes in each list. Each participant received only one list, and approximately one-sixth of the participants was assigned to each list.

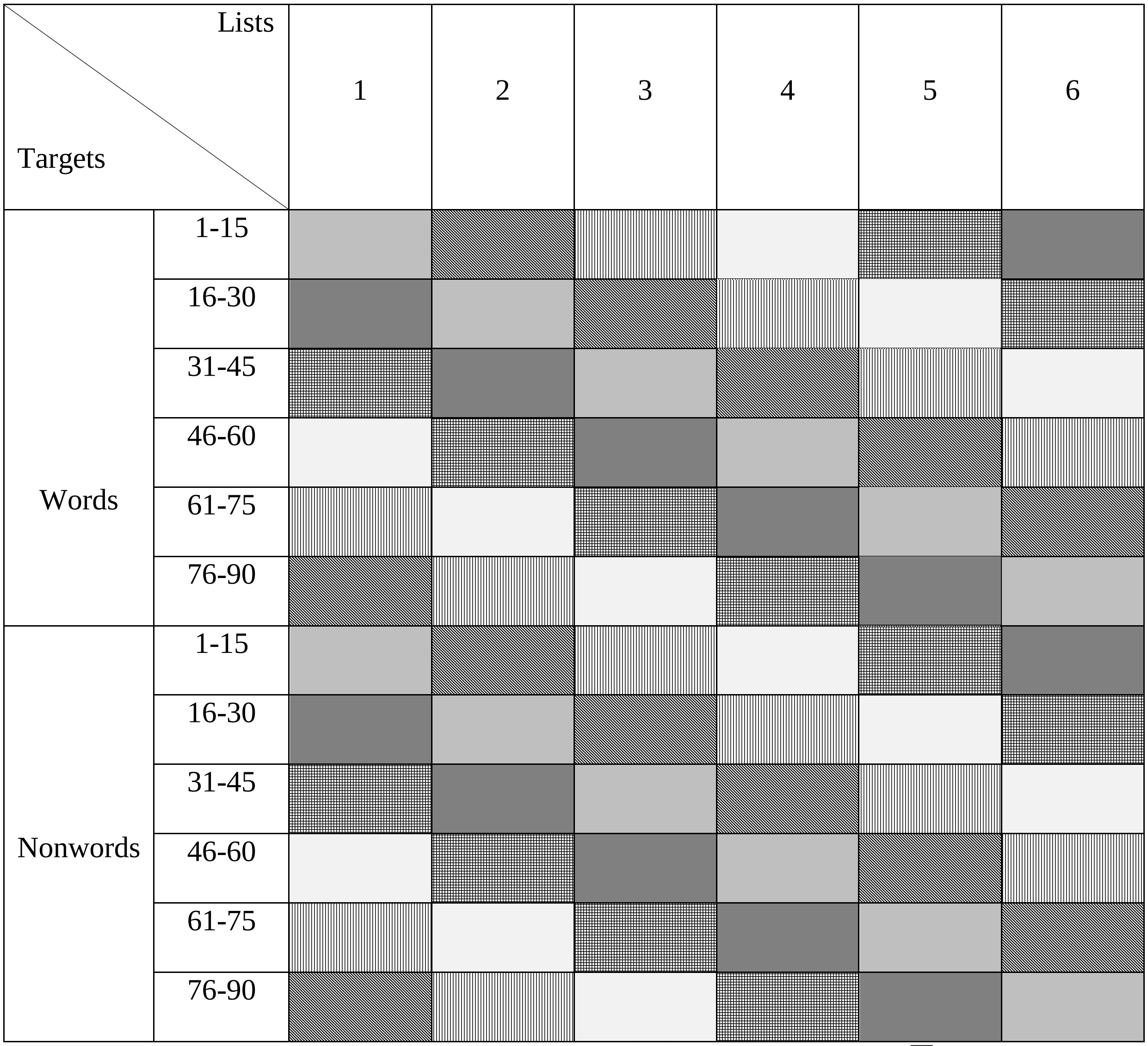

Figure 3. Visual representation of counterbalancing. TL O-O condition; TL C-C condition; TL C-O condition; RL O-O condition; RL C-C condition; RL C-O condition

Language experience questionnaire. Before the experiment started, participants were asked to complete a language experience questionnaire (Appendix E). The questionnaire was used to determine whether a participant met the selection criteria. There were two reading tasks at the end of the questionnaire. The first task was a multiple-choice reading question taken from the official Test of Proficiency in Korean (TOPIK). Participants were given a paragraph in Korean with brackets in the middle of one sentence and they were asked to choose the most appropriate of the various options to go into the brackets. This question was chosen because it required the ability to read and understand the context and to understand the meaning of a Korean idiom. The second task required participants to read out loud six Korean words. Some of these words had double-consonant letters, which are hard to pronounce for non-native Korean speakers. For example, in the first word 가까이, the second syllable's onset ㄲ is a double-consonant of the first syllable's onset ㄱ. Most people whose first language is not Korean and who are non-native Korean speakers cannot pronounce correctly the different sounds of ㄱ and ㄲ, and thus this task can be used as a measure of native-level fluency in Korean.

Procedure

Upon arrival, participants were given a letter of information briefly describing the general purpose of the study (Appendix A). After receiving the signed informed consent forms (Appendix B), participants were tested individually in a quiet room. Stimuli were presented in a different randomized order for each participant using DMDX software (Forster & Forster, 2003) on a Windows-based PC. On each trial, a mask consisting of six hash marks was shown for 500 ms. Next, a prime was presented for 50 ms, which was then replaced by a target. Participants were told that they would see combinations of letters and were asked to classify them as real Korean words or nonwords. Participants were instructed to give a response as quickly and as accurately as possible, by pressing the right shift key if they thought the letter combination was a real Korean word and the left shift key if they thought the letter combination was a nonword. Participants were not informed of the presence of primes. Each participant received 10 practice trials not involving any of the experimental stimuli and 180 experimental trials. Each experiment lasted no more than 20 minutes. At the completion of experiment, participants were fully debriefed (Appendix C).

Results

One participant was excluded from the data analyses because of an abnormally high error rate. Seven word items (경륜, 굿판, 길흉, 실낱, 훌청 , 닻줄 , and 밑변) had very high error rates and thus were removed from the data analyses. Incorrect responses (6.0% of the data for word targets) and response times less than 250 ms or greater than 2000 ms (0.6% of the data for word targets) were excluded from the latency data. The median response times and error percentages from the subject analysis for the word data are presented in Table 2. Usage of medians was necessary to minimize the impact of long latencies. ANOVAs based on the participant and item response times and error rates were conducted based on a 2 (Prime type: transposition, replacement) x 3 (Position of transposition/replacement: O-O, C-C, C-O) x 6 (List: list 1, list 2,

Table 2

Median lexical decision times (in ms) and percentage of errors for word targets

	Type of Prime		
	TL (ER %)	RL (ER %)	TL Priming
Onset1-Onset2 (O-O)	753 (8.9)	735 (4.9)	-19 (-4.0)
Coda1-Coda2 (C-C)	731 (7.6)	700 (6.4)	-31 (-1.2)
Coda1-Onset2 (C-O)	715 (7.0)	729 (6.3)	14 (-0.7)

Note: TL = Transposed-Letter prime, RL = Replacement-Letter prime, ER = error rate. Negative numbers in the TL Priming column indicate inhibition effects.

list 3, list 4, list 5, list 6) design. List was included as a dummy variable to extract variance due to counterbalancing.

The ANOVA on the latency data showed a significant interaction between prime type and position of transposition/replacement, $F_1(2, 34) = 5.13$, $MSE = 6115$, $p < .05$; $F_2(2, 152) = 4.06$, $MSE = 100965$, $p < .05$. The main effect of position of transposition/replacement reached significance only in the subject analysis, $F_1(2, 34) = 4.01$, $MSE = 10442$, $p < .05$; $F_2(2, 152) = 1.70$, $MSE = 44296$, $p > .10$. The main effect of prime type was not significant, $F_1(1, 17) = 1.61$, $MSE = 4699$, $p >.20$; $F_2(1, 76) = 2.05$, $MSE = 52665$, $p >.10$.

In order to investigate the interaction further, simple main effects tests of the prime type effect were done for each level of the position factor. The 19 ms transposed-letter prime disadvantage when the transposition took place between the onsets was significant but only in the item analysis, $F_1(1, 17) = 1.62$, $MSE = 2435$, $p >.20$; $F_2(1, 77) = 4.21$, $MSE = 141710$, $p <.05$. The 31 ms transposed letter disadvantage in the C-C condition was significant in the subject analysis, and marginally significant in the item analysis, $F_1(1, 17) = 7.17$, $MSE = 10706$, $p <.05$, $F_2(1, 76) = 3.29$, $MSE = 67660$, $p = .07$. The 14 ms facilitation effect in the C-O condition was not significant in either analysis, $F_1(1, 17) = 1.65$, $MSE = 1376$, $p >.20$, $F_2(1, 77) = 2.74$, $MSE = 20626$, $p > .10$.

The ANOVA on the word error data indicated a marginal effect of prime type in the subject analysis and a significant effect of prime type in the item analysis, $F_1(1, 17) = 3.65$, $MSE = .013$, $p = .07$, $F_2(1, 77) = 3.99$, $MSE = .05$, $p <.05$. There were fewer errors following replacement letter primes. The only effect in the nonword data was a marginal interaction effect in the subject analysis, $F_1(2, 34) = 3.03$, $MSE = .01$, $p = .06$, $F_2(2, 154) = 1.04$, $MSE = .02$, $p >.30$. No other effects in the nonword data approached significance.

Discussion

Lee and Taft's (2009) basic argument was that TL nonwords do not activate their base words due to the nature of Korean (i.e., the physical structure of Korean reduces the ambiguity of letter positions which eliminates the possibility of TL effects). Hence there should be no inhibition in their task and no facilitation in a masked priming LDT. The present results indicate some evidence of TL facilitation only in the C-O condition (e.g., *nakpin-NAPKIN*). However, the simple main effects analyses produced no good evidence that the effect is real. Thus, Lee and Taft's general point about Korean may be correct, that TL primes do not facilitate processing of their base words.

What is puzzling about the results of the present study, however, are the inhibitory effects following transposed O-O (e.g., *kapnin-NAPKIN*) and C-C (e.g., *nankip-NAPKIN*) TL primes. Although inhibitory effects of TL primes are not unheard of in other languages (Andrews & Lo, 2011), if Lee and Taft (2009; 2011) are correct, transposed letter primes should have had no effect at all in Korean. Therefore, these results would appear to require further research/discussion.

Previous literature (Davis & Lupker, 2006) reported inhibitory priming effects when target words were primed with orthographically related words (e.g. *attitude-APTITUDE)*, presumably due to "lexical competition". The idea is that when two words similar in form are presented one after the other, the first word is sufficiently activated both by its presentation and the presentation of the orthographically similar second word that it competes with the second word for resources required for lexical processing (e.g., for activation). In the present experiments, the primes were, of course, nonwords rather than words, however, it is not impossible that a similar inhibition process may be at work due to the nature of Korean.

In Korean, about 60 percent of words are Sino-Korean words, which are Chinese-character based words (Sohn, 2001). Most of these Sino-Korean words are bisyllabic, and most of the word stimuli used in the current study are Sino-Korean words. If one considers that each of the syllables in these Chinese-based words comes from one Chinese character, and that Chinese characters can stand on their own as words, one could suggest that each of these Chinese-based syllables in Korean can be represented as a unit in the reader's lexicon. For instance, 남북 (*nambuk*; literal meaning: *south-north*) is one of the word targets that was used in the present experiment, and it is a Sino-Korean word. The first syllable 남 can stand on its own as a word to mean South, and the second syllable 북 can also stand on its own as a word meaning North. The inhibition effects found in the present study may reflect some sort of competition between syllables of primes and targets. In other words, syllables in Korean may act like words in English and inhibit similar syllables, thus producing a syllable-syllable inhibition in Korean, just like the word-word inhibition effect in English. So, a reader getting the syllable precisely right in Korean may be quite important, more so than in other languages.

This type of analysis would explain why there is little evidence of orthographic priming in Korean and, in fact, what evidence there is suggests the primes orthographically similar to the targets actually produce inhibition when compared to dissimilar primes (Lee & Choi, 2009). Lee & Choi's (2009) work involved using a masked priming LDT with primes that were essentially the same as the RL primes used in the present study: RL O-O and RL C-C (their study did not involve TL nonwords). The important point is that the RL nonword trials had much slower reaction times than the trials with control nonwords, which shared no letters with target words. Therefore, it appears that the basic effect of orthographic similarity in Korean is inhibition rather than facilitation, unlike what is true in other languages.

What this fact would not explain, of course, would be why the TL primes produced even longer latencies than replacement primes. To explain that pattern, one has to argue that TL effects do exist in Korean. That is, the claim has to be that when a transposition of letters across syllables occurs in Korean, the two syllables that are produced are quite similar to the syllables in the base word due to the fact that the missing letter from each syllable exists elsewhere in the word. For instance, the TL C-C nonword 낙붐 (*nakbum*) has all letters of the base word 남북 (*nambuk*), whereas the RL C-C nonword 낟붓 (*nadbut*) has four out of the six letters. Those transposed letter syllables may inhibit the processing of the correct syllables in the base word to an even greater degree than simply syllables sharing two of three letters, slowing processing to an even larger degree Essentially, the argument is that not only do TL effects exist in Korean, they manifest themselves in a different way than in other languages.

There are a number of ways of extending and examining these ideas. Future research may begin by revisiting Lee and Taft's (2011) results. No TL effects were found when the onset and the coda were transposed within a syllable. An obvious question is whether there will be inhibition with within-syllable transpositions in a masked priming LDT. A second idea follows from Lee and Taft showing that it is possible to observe facilitory TL effects in Korean when the letters of complex codas are transposed. They suggested that because both letters in a complex coda serve the same function within a syllable, the order of the two complex coda letters is not encoded quite so unambiguously as the positions of other letters. In other words, a nonword can activate its base word as long as each syllable maintains the same letter combinations as the base word and the subsyllabic function of each letter in the base word remains the same. So, if one were to replicate the Lee and Taft's results using masked priming LDT in Korean, one might expect some sort of facilitation effect (e.g., to use an English analogy, *bankrutp* and *baknrupt* might facilitate *BANKRUPT* whereas *bankpurt* and *nabkrupt* do not). On the other hand, given that the general pattern in Korean is inhibition due to orthographic similarity, one might, instead, find inhibition in this situation as well.

It was also found that Koreans are faster in distinguishing nonwords when letter-changes were in the first syllable than the second (Lee & Taft, 2011). However, some questions arise based on the stimuli those authors used. Consider their presented examples of transposed-letter and replaced-letter nonwords (TL nonword 렵장; RL nonword 렵상) in their first syllable conditions. Both nonwords start with the syllable 렵. Although there are many words in Korean that have the consonant ㄹ as an initial syllable onset, words that start with the onset-vowel combination 려 or the syllable 렵 are extremely rare, if not nonexistent. The nonwords in the second syllable position conditions (TL nonword 신엽 ; RL nonword 신겹), on the other hand, contain the more frequent syllable 신 (syllable frequency 28918 per 3 million words, which is 65th most frequent syllable; according to Kim, 2005). To be fair, Lee and Taft did note that the frequency of the first syllables of the first-syllable condition was much lower than that of the second-syllable condition. However, the point remains that Lee and Taft's manipulation was confounded with syllable frequency raising concerns about the implications of their results. This issue also needs to be resolved in order to understand the importance of syllable processing to Korean readers.

Another suggestion for future research would be to investigate transposed *syllable* effects in Korean. The well-known Cambridge University e-mail demonstrates TL effects in English.

> Aoccdrnig to a rscheearch at Cmabrigde Uinerytisy, it deosn't mttaer in waht oredr the ltteers in a wrod are, the olny iprmoetnt tihng is that the frist and lsat ltteer be at the rghit pclae. The rset can be a toatl mses and you can sitll raed it wouthit porbelm. Tihs is bcuseae the huamn mnid deos not raed ervey lteter by istlef, but the word as a wlohe.

What is of more interest is that this e-mail has a translated Korean version:

> 캠릿브지 대학의 연결구과에 따르면, 한 단어 안에서 글자가 어떤 순서로 배되열어 있는가 하것는은 중하요지 않고, 첫째번와 마지막 글자가 올바른 위치에 있것는이 중하요다고 한다. 나머지 글들자은 완전히 엉진창망의 순서로 되어 있지을라도 당신은 아무 문없제이 이것을 읽을 수 있다. 왜하냐면 인간의 두뇌는 모든 글자를 하나하나 읽것는이 아니라 단어 하나를 전체로 인하식기 때문이다.

The difference between the English version and the Korean version is that the Korean version transposes syllables within phrases, unlike the English version where letters are transposed within words. Unlike the English script, in which spaces are placed between words, the orthographic structure of the Korean script places spaces between phrases (e.g., noun phrases, verb phrases), and one phrase contains at least one syllable. Lee and Taft's (2009; 2011) suggested that syllables are an important lexical processing unit in the process of visual word recognition because the physical distinction of syllables is clearly defined by orthographic syllable blocks. In other words, consistent with what is apparent in the Korean version of the Cambridge e-mail, Lee and Taft argue that syllables are the building blocks of written Korean. It is possible, then, that having the right combination of syllables is as important in Korean word recognition as having the right combination of letters is in English word recognition. Therefore, it might be easy to produce transposed syllable effects in Korean. Obtaining empirical evidence for transposed syllable effects in Korean is certainly something that should be attempted..

In summary, the present research supports Lee and Taft's (2009) claims that no facilitory TL effects are found in Korean due to the unique orthographic structure of the language. The presence of inhibitory TL effects, however suggests not only that the process of visual word recognition differs from one language to another, depending on the orthographic structure of the language, but also that TL effects do exist in Korean. Syllables in Korean are physically defined by preset visuospatial cues and may be a basic unit that plays a crucial role in the early stages of Korean word recognition. Further assessment of word recognition in Korean should reveal more about how humans process visually presented words and how such processes are language-dependent.

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Appendix A
Letter of Information

Project Title: A Korean Word Reading Study (Transposed Letter Effects in Korean)

Principal Investigator:

Arum S.Y. Jeong, Psychology Undergraduate, UWO

Steve Lupker, PhD, Department of Psychology, UWO

Letter of Information and Consent

1. Invitation to Participate

You are being invited to participate in a research project looking at Korean word recognition because you are a native speaker of Korean.

2. Purpose of the Letter

The purpose of this letter is to provide you with information required for you to make an informed decision regarding participation in this research.

3. Purpose of this Study

The purpose of this study is to investigate importance of letter-position information in the process of word recognition. The objective of this study is to evaluate previous research on word recognition in Korean.

4. Inclusion Criteria

Individuals who meet the following criteria are eligible to participate in this study:

1) A native speaker of Korean
2) 18 years of age or older
3) Have lived in Korea for 10+ years.

5. Exclusion Criteria

Individuals who are under 18 years of age and/or who do not use the Korean language every day are not eligible to participate in this study.

6. Study Procedures

If you agree to take part in this study, you will be asked to complete a short questionnaire that contains questions about where you were born, how long you lived in your place of birth, how long you have lived in Canada, and your most frequently used language at home and with friends. Once you complete the questionnaire, you will be asked to identify items shown on a computer screen as either a Korean word or a non-word by pressing designated keys on the keyboard. It is anticipated that the entire task will take approximately 15 minutes, over one session. The task will be conducted in the Social

Science Centre room 7219 in the UWO main campus. There will be a total of 42 participants.

7. Possible Risks and Harms

There are no known or anticipated risks associated with participating in this study.

8. Possible Benefits

You may not directly benefit from participating in this study but information gathered may provide benefits to society as a whole which may include a better understanding of how the human brain recognizes words and may lead to the development of a more efficient program for children to learn how to read.

9. Compensation

You will not be compensated for your participation in this research. However, if you are an undergraduate student who is currently taking the Psychology 1000 course, you will receive one-half participation credit for your time. If you do not complete the entire study you will still be given one-half participation credit.

10. Voluntary Participation

Participation in this study is voluntary. You may refuse to participate, refuse to answer any questions or withdraw from the study at any time with no effect on your future academic status.

You do not waive any legal rights by signing the consent form.

11. Confidentiality

All of your responses will be recorded without any links to personal identification to ensure anonymity and confidentiality. All data collected will remain accessible only to the investigators of this study. If the results from this study are published, no information that can identify you will be used.

Representatives of the University of Western Ontario Research Ethics Board may look at the study records and at your personal information to check that the information collected for the study is correct and to make sure the study followed proper laws and guidelines.

12. Contacts for Further Information

If you have any questions about the study, you may contact me, Arum Jeong at ajeong@uwo.ca or my instructor, Professor Steve Lupker at lupker@uwo.ca

If you have any questions about your rights as a research participant or the conduct of this study, you may contact The Office of Research Ethics (519) 661-3036, email: ethics@uwo.ca.

13. Publication

If the results of the study are published, your name will not be used. If you would like to receive a copy of any potential study results, please contact me, Arum Jeong at ajeong@uwo.ca or my instructor Professor Steve Lupker at lupker@uwo.ca.

This letter is yours to keep for future reference.

Appendix B
Informed Consent

Project Title: Transposed Letter Effects in Korean

Study Investigator's Name: Arum S. Y. Jeong

I have read the Letter of Information, have had the nature of the study explained to me and I agree to participate. All questions have been answered to my satisfaction.

Participant's Name (please print): ______________________________

Participant's Signature: ______________________________

Date: ______________________________

Person Obtaining Informed Consent (please print): ____________________

Signature: ____________________

Date: ____________________

Appendix C
Debriefing Sheet

A Korean Word Reading Study (Transposed Letter Effects in Korean)

Thank you for participating! The present study investigates transposed letter effects in Korean. Transposed letter (TL) effects refer to the fact that readers often misinterpret a nonword this is created by transposing letters within a real word, as that word. For example, *nakpin*, a nonword generated from transposing letters of the base word *napkin*, can be mistakenly read as *napkin*.

Lee and Taft (2009; 2011) investigated TL effects in Korean and in English using a lexical decision task, a task that involves classifying items as words or nonwords. Significant TL effects were observed in English, whereas no TL effect was observed in Korean. The authors proposed that this difference was due to orthographic structure differences in the two languages. English is a linear, alphabetic script, whereas Korean is a non-linear, syllabic script with predetermined letter positions. Those facts give an advantage to Korean readers in terms of accurately processing letter location compared to readers of linear scripts (e.g., English). The authors also suggested that subsyllabic processing may be important for word recognition in non-linear scripts.

The current study attempts to evaluate these conclusions (Lee & Taft, 2009; 2011). This study involves lexical decision task with masked primes, the method used in most of the studies in the literature examining TL effects (e.g. Lupker, Perea & Davis, 2008). Masked priming involves presenting a mask, a prime, and a target item. The primes are presented for a very brief time and most participants are unaware of them. The question is whether TL nonword primes will facilitate processing in Korean like it does in English or whether Lee and Taft's conclusions about the differences between languages are correct.

If you have any questions or concerns regarding this study, please feel free to contact Arum Jeong (ajeong@uwo.ca) or Steve Lupker (lupker@uwo.ca). If you have any questions about your rights as a participant, you may contact the Office of Research Ethics at the University of Western Ontario by phone (519-661-3036) or by email (ethics@uwo.ca).

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Appendix D
Complete List of Targets and Primes Used

Word Target	TL O-O	TL C-C	TL C-O	RL O-O	RL C-C	RL C-O
경륜	령균	견릉	결윤	평튠	겻륜	겸균
낙향	학냥	낭햑	낳강	닥량	낫함	낲장
덥석	섭덕	덕섭	덧벅	텁적	던섬	덩퍽
말벗	발멋	맛벌	맙럿	날덧	막벙	맞헛
맞선	샂먼	만섲	맛전	팢번	망석	맏컨
받침	찬빔	밤친	밪딤	갇짐	발친	밧킴
빈혈	힌별	빌현	빙녈	친셜	빔혁	빙멸
살갗	갈샃	샃갈	삭랓	발앗	삼각	산핮
졸업	올접	좁얼	종럽	놀펍	좋얼	좀컵
콧등	돗킁	콩듯	콛승	홋룽	콘듷	콕붕
팀장	짐탕	팅잠	팃망	림낭	틱잡	팃당
풍습	숭픕	픕승	풋읍	중츱	풀슥	풍큽
헛일	엇힐	헐잇	헝실	벗닐	헉읻	험칠
혹은	옥흔	흔옥	홍근	복즌	홈읏	홀든
흠칫	츰힛	흣침	흫밋	음빗	흑칯	흔릿
겁탈	텁갈	걸탑	걸발	컵할	겊탄	건말
남북	밤눅	낙붐	납묵	탐훅	낟붓	낭푹
돌솥	솔돋	돝솔	돗롵	골촐	돟솝	돋옽
번역	언벽	벅연	벙녁	먼젹	벙젼	벌셕
빙긋	깅븟	빗긍	빅읏	팅늣	빛긏	빌큿
숲길	굺실	술깊	숙필	줖닐	숭깅	숩킬
약혼	햑온	얀혹	양곤	댝본	얌홋	얄론
음식	슴익	윽심	읏믹	름힉	은싯	을빅
젓갈	것잘	절갓	적살	멋할	접간	젘알
정품	펑줌	점풍	젚움	덩쿰	절품	젛숨
첨단	덤찬	천담	첟만	섬한	청닥	첲반
측량	륵창	층략	츨강	즉샹	츱댱	츤퍙
탑승	삽틍	탕습	탓븡	답릉	탈슷	탚긍
헝겊	겅헢	헢겅	헣업	덩벞	헐겇	헐넢
협동	뎝홍	형돕	혇봉	섭공	혐돌	현롱

Word Target	TL O-O	TL C-C	TL C-O	RL O-O	RL C-C	RL C-O
겉옷	얻곳	것옽	겅톳	벋촛	겆옥	겊홋
굿판	풋간	군팟	궆산	뭇안	굽잔	궂탄
늦봄	봊놈	늠봊	늡좀	훚솜	늘봊	늘곰
덕분	벅둔	던북	덥군	억춘	덜붚	덧훈
병실	셩빌	별싱	볏일	졍닐	병싶	벅킬
승낙	능삭	슥낭	슨악	뭉착	슬박	슾작
육촌	축온	윤축	윷곤	둑손	율촘	윱폰
입학	힙악	익합	잏박	킵막	읻락	잇착
줄곧	굴졷	줃골	죽론	불온	줒골	준몯
질겁	길접	집걸	직렵	칠섭	짐겅	짇헙
콩팥	퐁캍	콭팡	콮앝	봉샅	콤팍	콜닽
탐욕	암톡	탁욤	탕목	밤혹	탓욜	탚독
특징	즉팅	틍직	틏깅	측닝	틈질	틉핑
폭음	옥픔	폼윽	퐁금	촉즘	폰읍	폴슴
흉물	뮹휼	휼뭉	흄울	숑줄	휸뭊	흅굴
금빛	븜깇	긏빔	급밎	틈닟	긒빈	글싳
길흉	힐귱	깅휼	깋륭	질큥	깃륭	닐듕
면접	젼멉	멉전	멪넙	뎐럽	멱졈	몃업
물건	굴먼	문걸	묵런	훌선	뭄겅	뭍언
밤낮	남밪	밪남	반맞	람찾	받낭	박닺
성함	형삼	섬항	섷암	령밤	석한	섯탐
순찰	춘살	술찬	숯날	분달	숨착	숲알
실낱	닐샅	싵날	신랕	힐같	싯납	싱찰
얼핏	펄잇	엇필	엎릿	걸칫	업핑	엊닛
장님	낭짐	잠닝	잔임	항림	잘닠	잪김
진담	딘잠	짐단	짇남	틴참	징답	직캄
촛불	봇출	출봇	촙술	곳풀	총불	촉툴
칼슘	살큠	캄슐	캇륨	갈쥼	칸슢	칻윰
통합	홍탑	톱항	톻압	봉잡	톡핫	톨합
홑청	촡형	홍첱	홏텽	솥멍	혼녕	홉척

Word Target	TL O-O	TL C-C	TL C-O	RL O-O	RL C-C	RL C-O
곤충	촌궁	공춘	곶눙	론붕	곰춧	곶풍
녹즙	족늡	놉즉	놎급	축습	높즌	농릅
단점	잔덤	담전	닺넘	판엄	닥젓	닥번
독립	록딥	돕릭	돌깁	옥밉	돈림	돗집
밉상	십망	밍삽	밋방	깁당	밎산	밎창
볏짚	졋빞	볖짓	볒싶	혓딮	병직	볌맆
설명	멀셩	성멸	섬령	널경	섶면	섷멸
송편	퐁션	손평	솦연	공텬	솓펩	속면
앞문	맢운	안뭎	암푼	랖준	악뭍	앛훈
연못	면옷	엿몬	염놋	현봇	역몰	엳톳
창틀	탕출	찰틍	찰읕	망슬	찬특	찹즐
큰절	즌컬	클전	큿널	슨덜	큽정	큿멀
풋말	뭇팔	풀맛	품살	곳달	풍만	풀발
한턱	탄헉	학턴	할넉	칸먹	항텁	합럭
홈연	옴현	혼염	홍변	촘션	홀역	홈전
간섭	산겁	갑선	갓넙	단멉	갈성	갖첩
균형	휸경	귱현	궇녕	뷴명	귤혓	귤졍
넝쿨	컹눌	널쿵	넉울	성툴	넉쿳	넣둘
당근	강든	단긍	닥은	상픈	닿글	담른
닻줄	잧둘	달줓	닺출	낯굴	닷줌	달올
문득	둔믁	묵든	묻늑	운큭	뭋들	묶븍
밑변	빝면	민볕	밉텬	실연	밋련	믹면
벌금	걸븜	범글	벅름	컬츰	번긍	벋름
불혹	훌복	북홀	붛록	울측	붓홈	분족
석방	벅상	성박	섭강	헉낭	섥발	섬팡
암컷	캄엇	앗컴	악멋	잠덧	알컥	안벗
온갖	곤앚	옺간	옥낮	혼샂	옴캇	올닺
팝콘	캅폰	판콥	팍본	압톤	팣콜	팜촌
필통	틸퐁	핑톨	핕롱	실홍	핌톷	핀종
훗날	눗할	훌낫	훈살	웃팔	훛갈	훅탈

Nonword Target	TL O-O	TL C-C	TL C-O	RL O-O	RL C-C	RL C-O
갈층	찰긍	강츨	갗릉	날흥	감츷	갑승
궁팁	퉁깁	굽팅	궆입	룽닙	굴핍	궁밉
능펼	픙널	늘평	늪열	증멸	늣폡	늠떨
만얄	안말	말안	망날	탄할	막얍	맛댤
박힝	학빙	방힉	밯깅	막팅	반힌	발싱
붓직	줏빅	북짓	붖식	룻칙	붕짐	붕닉
속옴	옥솜	솜옥	송곰	폭홈	손옻	솔톰
슬븜	블슴	븜슬	습름	플금	슥붕	슨즐
억잡	적압	업작	엊갑	덕납	얼잦	얻맙
울덕	둘억	욱덜	욷럭	술넉	윤덤	웊적
잠볼	밤졸	장봄	잡몰	남촐	잣골	잔올
정락	렁작	적랑	절악	덩막	전랍	젘삭
참잇	암칫	찻임	창밋	함짓	찬임	찹깃
핍약	입팍	픽압	핑박	킵학	필알	핏낙
혹싱	속힝	홍식	홋깅	즉링	홋싶	흔빙
걸슴	설금	검슬	것름	덜븜	겅슾	걸늠
낭복	방녹	낙봉	납옥	창툭	낳볼	낟속
둔랍	룬답	둡란	둘납	준삽	둪랑	둑찹
멸통	텰몽	명톨	멸롱	셜동	몁톤	멱퐁
방먼	망번	반멍	밤언	팡선	박멀	밝전
볼퐁	폴봉	봉폴	뵾롱	놀뭉	봇플	복쿵
손막	몬삭	속만	솜낙	온락	솔맙	솧닥
숭늠	능숨	숨능	순음	궁름	숟늪	숩픔
압숙	삽욱	악숩	앗북	합눅	앋숲	악룩
익할	힉알	일학	잉갈	딕살	읻한	잇칼
족솔	속졸	졸속	좃골	복폴	종손	존홀
증곤	긍존	즌공	즉온	릉론	즉곳	즙돈
칠옥	일측	칙올	칭록	밀슥	친옥	칲득
탈팍	팔탁	탁팔	탚락	할삭	탐팡	탓박
홀빗	볼힛	홋빌	홉릿	출잇	홈빈	혹딧

Nonword Target	TL O-O	TL C-C	TL C-O	RL O-O	RL C-C	RL C-O
갑올	압골	갈옵	강볼	캅몰	간올	갖돌
깃텁	팃겁	깁텃	길섭	힛덥	깊턴	깆럽
독범	복덤	돔벅	돕검	촉럼	돌벌	동컴
득낭	늑당	등낙	든강	특항	듯장	듬방
반룩	란북	박룬	발눅	단푹	밤룻	방툭
빌딕	딜빅	빅딜	빋릭	힐익	빞딕	빈식
솜벌	봄설	솔범	솝멀	롬걸	송벚	속컬
습혹	흡슥	슥흡	슿복	츱즉	슨홀	슴록
열잠	절암	염잘	엊람	걸참	엳작	엽낙
잘몹	말좁	잡몰	잠롭	살곱	작뭎	장놉
종밧	봉잣	좃방	좁앗	롱핫	졸받	죽낫
청겸	경첨	첨경	척염	헝볌	철겻	천셤
탁산	삭탄	탄삭	탓간	닥잔	탕삽	탈만
편겅	견펑	펑건	펵넝	션렁	펍겇	펌컹
향란	랑한	한랑	할안	팡간	햧람	합산
골몬	몰곤	곤몰	곰론	롤손	곱몽	곺촌
늑잘	즉날	늘작	늦갈	븍찰	늠잔	늑알
덩군	겅둔	던궁	덕운	성룬	덜굼	덧준
막삽	삭맙	맙삭	맛갑	박답	맣삭	만랍
별임	열빔	볌일	병림	결님	볕읻	볏힘
복현	혹변	본혁	봏견	촉연	볼혓	봄견
삼총	참송	상촘	샂몽	잠콩	삽촐	산홍
숙첨	축섬	숨척	숯검	욱펌	숭철	숯널
심종	짐송	싱좀	싲몽	림공	십동	식농
엄벅	범억	억범	업먹	텀퍽	언벌	엇덕
윤살	순알	율산	윳날	륜탈	윶삵	육발
준첩	춘접	줍천	줓넙	푼섭	줌척	중렵
총칵	콩착	촉캉	촠악	롱낙	촐캅	촛막
톰납	놈탑	톱남	톤발	옴팝	톳낙	톤합
항몰	망홀	할몽	함올	낭솔	합뭎	학졸

Nonword Target	TL O-O	TL C-C	TL C-O	RL O-O	RL C-C	RL C-O
검별	범결	걸볌	겁멸	첨펼	겇벽	경혈
급홍	흡궁	긍훕	긓봉	즙콩	긎훗	근퐁
늘삼	슬남	늠살	늣람	글잠	능삽	늘함
등녹	능독	득농	든옥	픙콕	듯놀	듲속
묵향	흑망	뭉학	뭏강	륵창	문핲	뭋캉
본달	돈발	볼단	볻날	콘살	봉담	봎찰
빗듬	딧븜	빔듯	빋슴	릿금	빙든	빚즘
숯울	웇술	술웇	숭출	훛굴	숲움	순둘
신줌	진숨	심준	싲눔	빈굼	싯줄	실훔
얌헌	함언	얀험	얗먼	캄런	얍헐	얏건
욺덥	둚업	욻덜	윤럽	훌겁	움덫	웃첩
적번	벅전	전벅	접건	먹런	전벙	절펀
촌강	곤창	총간	촉낭	손캉	촘갖	촐탕
퐁답	동팝	폽당	폳압	농맙	폿닻	폴갑
힘굴	김훌	힐굼	힉물	임둘	힛군	힐쿨
감흔	함근	간흠	갛믄	암른	갇흡	갓즌
넙축	첩눅	넉춥	넟북	멉푹	녘충	널북
덧빌	벗딜	덜빗	덥실	헛닐	덩빅	덪필
둥십	숭딥	둡싱	둣입	궁밉	둔싯	둑립
발윤	알뷴	반율	방륜	잘균	밧윷	발뮨
벽돔	뎍봄	볌독	볃곰	역롬	변둥	볏폼
삽익	압식	삭입	상빅	납틱	삿일	상믹
싱늘	닝슬	실능	신을	빙믈	식늑	실글
염북	범욱	역붐	엽묵	렴훅	역붓	연쿡
옥삽	속압	옵삭	옷갑	독잡	올삭	옴합
잡속	삽족	작솝	잣복	탑녹	잦솔	잠콕
즉룽	륵중	중륵	즐긍	측붕	즘룰	즛풍
철작	절착	척잘	첮락	설팍	첩잔	청악
침곳	김촛	칫곰	칙뭇	림돗	칭곤	칩좃
홀솜	솔홈	홈솔	홋롬	콜옴	홍손	혹촘

Appendix E
Language Experience Questionnaire

Participant #: ________________ Age: _______________ Gender: _______________

What is your country of birth? ________________________

How many years did you live in Korea? ____________________________

How many years have you lived in Canada? _________________________

What language is spoken more frequently at home with your family? ___________________

What language is spoken more frequently with roommates and friends? _________________

Experience with Korean

Please rate the extent to which you are fluent in the following aspects of Korean on a scale from 1 to 10, with 1 meaning that you are not fluent and 10 meaning that you are very fluent.

	not fluent									*very fluent*
Understanding	1	2	3	4	5	6	7	8	9	10
Speaking	1	2	3	4	5	6	7	8	9	10
Reading	1	2	3	4	5	6	7	8	9	10
Writing	1	2	3	4	5	6	7	8	9	10

Reading Task

➢ 다음을 읽고 ( ) 안에 들어갈 내용으로 가장 알맞은 것을 고르십시오.

> 사람이 감정을 표현하거나 억누르려고 할 때 눈은 통제가 어렵기 때문에 의지대로 잘 되지 않는다. 애써 감정을 억누르려고 해도 그 감정이 눈을 통해 새어 나오게 마련이다. 거짓으로 기쁜 척을 하려 해도 슬퍼 보이는 눈빛만큼은 어쩔 수 없다. 그리고 정말로 기쁠 때는 자기도 모르게 눈이 빛나기 때문에 당사자의 의지와 상관없이 상대방이 알아차리게 된다. 그래서 사람들이 ( ) 하는 것이다.

a. 눈을 마음의 거울이라고
b. 사람의 마음은 알기 어렵다고
c. 자신의 얼굴에 책임을 지라고
d. 눈에 보이는 것이 전부는 아니라고

➢ Please read the following words to the experimenter.

1) 가까이 2) 바깥 3) 생활 4) 진짜 5) 뜰채 6) 곗돈