한국심리학회지 : 인지 및 생물
The Korean Journal of Cognitive and Biological Psychology
2015, Vol. 27, No. 3, 561-581

The lexical inhibition of the phonological information in Korean visual word recognition*

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Two Experiments using a primed lexical decision task investigated what types of linguistic information elicits lexical inhibition during visual word recognition of Korean. We measured participants' reaction times for this task and three prime-target conditions were used: 1) orthographically related 2) phonologically related and 3) control condition. We attempted to examine how lexical competition occurs when prime words had phonological change and whether the inhibition is modulated by word frequency of prime words (Experiment 1), and investigate whether the lexical competition is modulated by lexical status of the prime stimuli (Experiment 2). In Experiment 1, we showed that the reaction times were slower in the phonologically related condition as compared to the control condition, whereas they were faster in the orthographically related condition relative to the control condition. Moreover, this tendency was more noticeable in the low frequency prime condition relative to the high frequency prime condition. However, neither the inhibitory effect by the phonologically related prime nor the facilitative effect of the orthographically related prime were observed in Experiment 2 in which nonword primes were used, suggesting that the inhibitory priming effect is generated due to lexical competition between the prime and the target within a lexical level, not via a pre-lexical level in Korean visual word recognition.

Key words : lexical competition, syllabic priming, phonological change

* 이 논문 또는 저서는 2013년 정부(교육부)의 재원으로 한국연구재단의 지원을 받아 수행된 연구 임 (NRF-2013S1A5A2A01019273).
이 연구는 2015년도 고려대학교 문과대학 특별연구비 지원을 받아 수행되었음(과제번호: K1505241).
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The question how orthographically and/or phonologically similar words affect lexical access of a particular word has been central issue to establish models of the visual word recognition (for a brief review, see Norris, 2013). During the processes of word recognition, readers have to find the right lexical entity among other lexical candidates. Accordingly, the lexical competition between the target word and other candidates should occur at a variety of levels of word recognition (Colombo, 1986; Davis & Lupker, 2006; Dufour & Peereman, 2003; Grainger & Jacobs, 1996; Lupker & Colombo, 1994; Monsell & Hirsh, 1998; Segui & Grainger, 1990). For example, Colombo (1986) reported a lexical competition effect in an unmasked priming study in which a prime word was presented for 320 millisecond, and then followed by a target. Using rhyming prime and target pairs (e.g. Ladre - Padre) the author found longer reaction times for the target word when the rhyming prime (e.g. Ladre) preceded a high-frequency target (e.g. Padre) as compared to when a control prime preceded the target, suggesting that the phonologically related prime word inhibit the processing of the target word, which suggests that lexical competition is generated between words with similar orthography and/or phonology (for other explanations for lexical inhibition, see Segui & Grainger, 1990).

Competitive processing can also be due to syllabic units in some languages like Spanish (Carreiras & Perea, 2002; Carreiras, Alvarez, & De Vega, 1993; Dominguez, Vega, & de Cuetos, 1997), German (Conrad, Grainger, & Jacobs, 2007), and Korean (Kwon, 2009). For example, Dominguez et al. (1997) used an unmasked priming lexical decision task with 250 millisecond SOA to examine whether an overlapping syllabic unit between the prime and target elicits additional inferences above and beyond the letter overlap by manipulating two variables; the number of common initial letters and syllabic consistency (e.g. nor/ma-nor/te, no/ria-nor/te, man/do- nor/te, and sa/via-nor/te), and found that participants showed longer reaction times in the condition having syllabic and letter consistency (e.g. nor/ma-nor/te) than in the letter consistent condition (e.g. no/ria-nor/te). The results suggest that the inhibitory effect arises when syllabic units of the prime and the target overlap, not just when the letters overlap between the prime and the targ et (Carreiras & Perea, 2002; Carreiras et al., 1993).

As like Spanish, Korean is a language with clear syllabic boundaries. Because each Korean syllable is written in as a character, which can be segmented quite easily, syllables might be the most important pre-lexical functional unit in Korean visual word recognition (Bae & Yi, 2010; Kwon, 2009; Kwon, Cho, Kim, & Nam,

2006; Nam, Kim, & Seo, 2001; Yi, 1993; Yoshitaka & Kim, 2004, 2005). Kwon et al. (2006) and Kwon (2009) tested the importance of syllables as a processing unit in the process of Korean visual word recognition, and argued that syllables are the fundamental processing unit. For example, Kwon et al. examined what kind of sub-lexical units was a source of the orthographic neighborhood density effect, which is a phenomenon that reaction times for a word that having many orthographically similar words are faster than ones for a word with a few (e.g. for a comprehensive review, see Andrews, 1997; Grainger, Muneaux, Farioli, & Ziegler, 2005; Mathey, Zagar, Doignon, & Seigneuric, 2006). They found the neighborhood density effect only when the neighborhood density was computed by overlap of the first orthographic syllable between the target word and other neighbor words. When the density was measured by overlap of the second syllable or of the body unit, the neighborhood density effect did not appear in a lexical decision task. This result indicates that the syllabic unit, in particular the first syllable, is the most meaningful processing unit in Korean visual word recognition.

Given that the syllabic unit is the most effective processing unit in Korean visual word recognition (Kwon, 2009; Kwon et al., 2006), it would be crucial to examine whether lexical competition occurs based on orthographic or phonological syllabic units. Specific characteristics of Korean allow one to test how the phonological and orthographic information of the first syllable affects Korean visual word recognition. The sound-to-spelling correspondence of Korean is quite consistent except for some cases where pronunciation should be changed due to the difficulty of articulation. The exceptional cases usually occur when a coda consonant in the first syllable phonologically interacts with the first onset consonant of the second syllable. This only occurs for a limited number of consonant pairs (e.g. the coda consonant /n/ is changed into /l/ as it meets with the onset consonant /l/, i.e., phonological assimilation). The "학", for instance, would be pronounced as /hak/ for a single syllable. But in a bi-syllabic word "학문" /haŋmŏn/, the first syllable "학" is pronounced as /haŋ/, instead of /hak/, because of a phonological rule requiring that the final consonant (coda) of the syllable is changed to the sound with the same place of articulation of the first consonant (onset) of the next syllable. Using this characteristics of phonological assimilation in Korean, Kwon (2009) manipulated the number of orthographic and phonological neighbor words of the bisyllabic Korean words and found that lexical decisions for the target words slowed down as the number of the neighboring words sharing the first phonological syllable increased,

suggesting that the inhibitory effect caused by the phonological syllable arises from lexical competition between the target and phonologically-related words at the lexical level. Similarly, Bae & Yi (2010) showed an inhibitory effect of the phonological syllable using a syllabic priming paradigm, suggesting that when a prime and a target share a phonological syllable, an inhibitory effect can occur on target word processing.

The purpose of the current study is to further examine how phonological and orthographic information are activated in Korean visual word recognition. We used words with phonological change (e.g., 학문) to manipulate the prime and target relation. As described earlier, Bae & Yi (2010) reported an inhibitory priming effect when a prime and a target shared a phonological syllable in the first syllabic position of a two-syllable word. However, it has been little studied how the lexical inhibition interacts with lexical properties like word frequency (cf. Segui & Grainger, 1990). Segui & Grainger (1990) reported an interaction effect between the priming pattern and the relative word frequency of the prime and target such that an inhibitory effect occurred when a prime word (e.g., char) had lower frequency relative to a target word (e.g., CHAT), however, no such effect was reported when a prime was a higher-frequency neighbor word of the target word. Segui & Grainger argued that the inhibitory effect of a higher-frequency target word occurs due to a lower-frequency prime word inhibits its competitors including the higher-frequency target word when the prime is recognized so that recognition of the target word becomes slower relative to the case where a prime word is orthographically and/or phonologically unrelated to the target. If this is also the case in Korean, a significant interaction effect between priming pattern and word frequency would occur such that the inhibitory effect would be greater when a lower-frequency prime word is presented as compared to when a higher-frequency prime word is used. The current study, in particular, is designed to answer three specific questions: 1) Can we replicate the phenomenon that lexical inhibition observed in a priming task occurs due to phonological representation of visual word recognition, 2) Is the phonological lexical inhibition modulated by lexical frequency, and 3) Is there any possibility that the phonological lexical inhibition occurs at pre-lexical processes of word recognition. In Experiment 1, we conduct a priming task to examine the first two specific questions by manipulating word frequency of the prime word. In Experiment 2, we investigate the third question by using nonword prime stimuli.

Experiment 1

Experiment 1 was conducted to examine the two specific questions on 1) which linguistic feature of prime words produce inhibition on a target word, orthographic or phonological representation, and 2) how the lexical inhibition is modulated by lexical frequency of prime words. Given that the inhibitory effect of a prime on a target appeared when the prime and target pair shared phonological representation (Bae, & Yi, 2010; Kwon et al., 2006), we would expect that the inhibitory effect is produced based on phonological information of a prime word, not orthographic information. With respect to the second question, if word frequency of prime words modulates lexical inhibition, we would expect more inhibition on a target word when a lower-frequency prime word is used relative to when a higher-frequency one is used because higher-frequency neighbor words including a target word should be inhibited in order to effectively recognize the lower-frequency prime word, which in turn takes more time to recognize the target word. However if lexical frequency does not affect lexical inhibition on target processing, it would not have any difference in inhibitory priming effect across the two frequency conditions.

Method

Subjects Twenty-seven participants (17 female students, mean age = 22.3 ranged from 19 to 25) who took an introductory psychology class participated in the experiment as a course requirement. They were all native Korean speakers, and they all had normal or corrected normal vision.

Stimuli As described in the introduction, we used specific features of the phonological change in Korean to examine how orthographic and/or phonological representation of a prime word affects recognition of a target word. Generally speaking, monosyllabic Korean words have very regular and transparent spelling-to-sound rules. But polysyllabic Korean words have various and complicated phonological change rules, which makes them have inconsistent representation between phonology and orthography of the words. For instance, a character (syllable) "근" is pronounced like /Geun/ when it is used by itself. However, the same character (syllable) "근" in a word, "근로" (It means a "labor"), should be pronounced to 글/Geul/, instead of 근 /Geun/ because the word "근로" generates phonological assimilation between the final consonant (coda) of the first syllable and the first consonant (onset) of the second syllable occurs. So the pronunciation of the first

character (syllable) of the word "근로" is converted to /Geul/. Accordingly, the first character (syllable), "근" of the word "근로" has two different phonological representation for the same character, /Geun/ or /Geul/.

Based on this characteristics of the bisyllabic Korean word, forty-two words that have phonological change based on the phonological assimilation were selected as the prime stimuli, half were high-frequency words, and the other half were low-frequency word. (average frequency was 784 per million vs. 33 per million, respectively). The characteristics of prime stimuli were presented in Table 1.

Three kinds of target stimuli were used in Experiment 1. Forty-two Korean words were allocated to each condition. Statistical tests showed that the target words of three groups did not differ from one another on any lexical characteristics (all ps > .05). The characteristics of the target stimuli were presented in Table 2. Both prime and target words were selected from

Table 1. The characteristics of the prime used in Experiment 1.

	Prime condition	
	High Frequency	Low Frequency
Word Frequency	784	33
Syllable Length	2	2
Number of Phonological neighbors	63.1	85.4
Number of orthographic neighbors	88.4	67.8

Table 2. The characteristics of the target words used in Experiment 1.

	Orthographic condition (OrthoRtd)		Phonological Condition (PhonRtd)		Control Condition (Ctrl)	
	Average	SD	Average	SD	Average	SD
Number of letters	5.67	0.48	5.52	0.50	5.45	0.59
Number of phonemes	5.5	0.55	5.36	0.66	5.33	0.65
Number of syllables	2	0	2	0	2	0
Word frequency	70.8	45.4	70.2	45.4	70.5	45.4
Number of Phonological neighbors	62.5	41.5	68.7	52.8	77.6	46.0
Number of orthographic neighbors	76.9	44.1	67.0	55.4	88.4	45.6

Suh (1998).

The critical conditions were the phonologically -related and orthographically-related conditions. The phonologically-related condition had the same phonological form between the first syllable of the prime and that of the target, but not the same as the orthographic form (PhonRtd). In contrast, the orthographically-related condition had a different phonological form between the first syllable of the prime and that of the target (OrthoRtd). For example, if the prime word was "근로"/Geul.lo/, the orthographic target word was "근저"/Geun.jeo/, and the phonological target word was "글귀"/Geul.gui/. The control condition had no phonological or orthographic overlap at all between the prime and the target (Ctrl, "백치"/Baek.chi/). All target stimuli were bi-syllabic words.

Procedure Participants were tested individually in a quiet experimental cubicle. Participants were first given instructions. After the participants indicated that they understood the task properly, they performed ten practice trials. Afterwards, the experimental run was started; no break was provided. In the lexical decision task (LDT), both the prime and the target were presented visually. Both the prime and the target were Batang font with a size of 20. Each trial consisted of: (1) a pattern mask "####" for 500ms; (2) a visual word prime for 80ms; (3) a white screen for 70ms (That is, a 150ms SOA between the mask and target); and (4) a target immediately following the white screen and presented until participants pressed a button on a keyboard. The task was a lexical decision task in which participants were asked to decide the lexicality of the target as quickly and accurately as possible and to press either Yes or No button. Their response was followed by a 1000ms inter-trial interval.

Design The experimental design was a 3 X 2 within-subjects design, in which there were 3 levels of prime-target relationships and 2 levels of prime word frequency. Three counterbalanced lists were made such that each prime word appeared in only one condition in a list. Although the list order was counterbalanced, each participant was shown all three lists. The order of presentation of events was randomized within each list. One list consisted of three kinds of prime conditions: phonologically-related (PhonRtd), orthographically-related (OrthoRtd), and controls (Ctrl). To prevent the participants from using a strategy, 42 filler trials were included in each list. For these fillers, we created 42 prime and target pairs.

In the present experiment, because we attempted to investigate how two different phonological information of the same character (syllable) of a prime word influence processing of

target words, we used a modified priming technique in which a common prime word was followed by different types of target words according to the three conditions. As mentioned earlier, the prime words used in this study had phonological change so that the first character (syllable) of them had two different phonological representation, one of which was active in a case where no phonological change occurs whereas the other was active when phonological change was generated due to the phonological characteristics of the second syllable. We were particularly interested in how these two inconsistent information of the prime word influence word recognition. That's why the modified version of priming experiment was administrated in this study. Due to this modification, different target words were used in each condition- each with lexical properties known to influence lexical processing (e.g. word frequency, number of letters and syllables, orthographic or phonological neighborhood, etc.) controlled (See table 2). In order to verify whether the control of lexical properties in each condition was effective, we performed a lexical decision task to the target words used in the three target conditions, and found that the base RTs across target conditions were very similar (average RTs were 601ms (PhonRtd) vs. 602ms (OrthoRtd) vs. 599ms (Ctrl), all Fs<1)). Accordingly, it might be argued that our use of different target items across the conditions was acceptable in this experiment.

Results

The result is shown in Figure 1. Incorrect responses were excluded from the analysis (5.7%), and the error rates were not systematically different across conditions ($F < 1$). Also, RTs less than 300ms or more than 2000ms were considered outliers and removed from the analyses. In total, 7.1% of data were excluded from the latency analysis.

An analysis of variance was done using subjects as a random variable (F_1), and using the stimuli as a random variable(F_2). The main effects of the prime and target relation were statistically significant ($F_{1(2,52)} = 17.63$, $p < .0001$; $F_{2(2,40)} = 4.50$, $p < .05$), but the word frequency of the prime words was not significant ($F_{(1,26)} = 2.79$, $p > .10$; $F_{(1,20)} = 2.04$, $p > .16$). The interaction between the target condition and prime frequency was statistically significant in the subject analysis, not in the item analyses ($F_{2(2,52)} = 3.55$, $p < .05$; $F_{(2,40)} = 2.24$, $p > .14$). As a post-hoc test, analyses of simple main effect were conducted on the response times and results showed a significant 31ms facilitation in the OrthoRtd condition as compared to the Ctrl condition (609ms vs. 640ms), ($F_{1(1,26)} = 16.89$, $p < .05$; $F_{2(1,20)}$

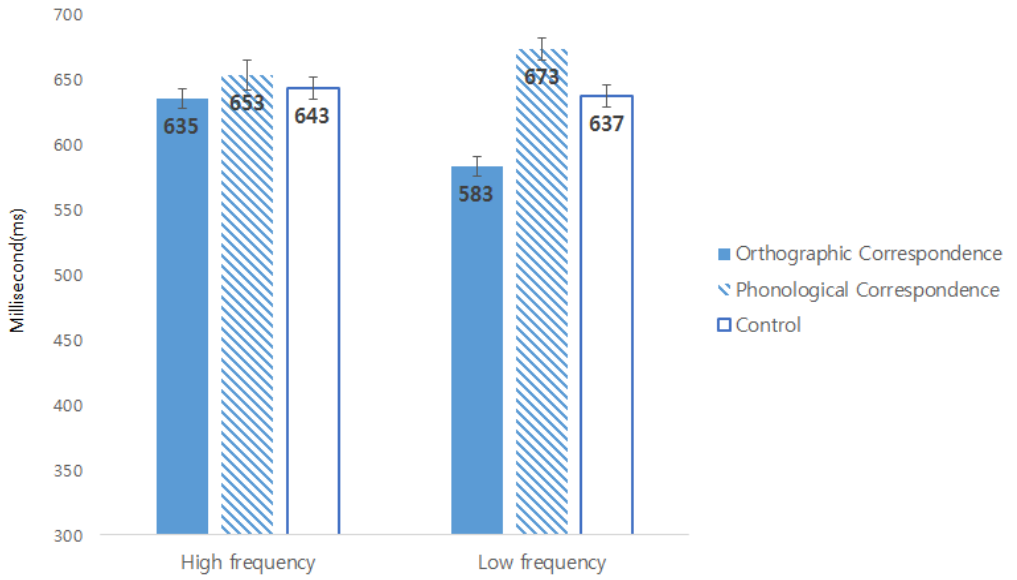

Figure 1. Reaction time (Mean and Standard Errors) across condition in Experiment 1

= 9.82, $p < .05$). In addition, we found a significant, 23ms inhibition effect in the PhonRtd condition as compared to the control condition (663ms vs. 640ms), ($F_{(1,26)} = 9.43$, $p < .05$; $F_{2(1,20)} = 8.12$, $p < .05$).

Discussion

The results of Experiment 1 supported the idea that lexical competition occurs during word recognition, as there was an inhibitory effect of the phonologically related word on the processing of target word, which is consistent with previous literature (Carreiras et al., 1993; Colombo, 1986; Conrad et al., 2007; Kwon, 2009; Segui & Grainger, 1990). Conrad et al. (1993) found that the reaction times for bi-syllabic words were longer when the first syllable of a bi-syllabic word was a high-frequency syllable versus a low-frequency syllable, suggesting that lexical competition occurs based on the phonological representation, not based on the orthographic representation of words. Kwon (2009) also showed that responses were slower to words with many phonological neighbor words than those with few phonological neighbors in a lexical decision task, indicating that phonologically related words might inhibit the processing of a target word.

Another interesting finding in Experiment 1 is the interaction effect in the subject analysis (and marginally significant in the item analysis) between the prime-target condition and word frequency of the prime word such that the

magnitude of the inhibitory effect by the phonological syllable (i.e., the PhonRtd – Ctrl) was bigger in the low-frequency condition as compared to the high-frequency condition, and the magnitude of the facilitative effect by the orthographic condition (i.e., the OrthoRtd-Ctrl) was bigger in the low- than high-frequency prime words. This result is consistent with the finding observed in previous studies (Colombo, 1986; Segui & Grainger, 1990). These results indicate that the lexical competition is modulated by word frequency. When a lower-frequency prime word is presented, it can inhibit its competitors that might be two-syllable words sharing the first phonological syllable, which leads target word processing to be harder because the target is likely to be a competitor of the prime word. However, when a higher-frequency prime word is presented, it does not have to inhibit other competitors because the prime word is higher-frequency word, which does not affect target word processing. Further discussion on this issue is to be done in the General Discussion.

Experiment 2

In Experiment 1, the inhibitory effect in the phonologically related condition (PhonRtd) was interpreted as the result of lexical competition within the lexical level (Colombo, 1986; Davis & Lupker, 2006; Dufour & Peereman, 2003; Hamburger & Slowiazek, 1996; Humphreys et al, 1988; McClelland & Rumelhart, 1986; Monsell & Hirsh, 1998; Lupker & Colombo, 1994; Segui & Grainger, 1990; Slowiaczek & Hamburger, 1992). The interpretation was that lexical competition between phonological competitors caused an inhibitory effect when target selection occurred. If that interpretation is correct, then non-word primes cannot have an inhibitory effect for targets because the nonword prime does not have lexical meaning (Lukatela & Turvey, 1990; Lupker & Colombo, 1994; cf. Dominguez et al., 1997). To address this issue, the present experiment used nonwords that have the same characteristics of phonological changes as stimuli used in Experiment 1. By applying the same logic from Experiment 1, we investigated how the phonological and orthographic information of a non-word prime affects processing of a visual target in a lexical decision task (LDT). If the slower RT by phonological overlap between a prime and a target relative to the control condition observed in Experiment 1 was due to lexical competition within the lexical level, nonword primes used in Experiment 2 could not inhibit the processing of a target word because the nonword primes have no lexical meaning. Alternatively, if the inhibitory effect obtained in Experiment 1 was based on the phonological overlap between the

prime and the target at a pre-lexical level, similar competitive effect could be generated when nonword primes are used in a LDT.

Method

Subjects Thirty participants (19 female students, mean age = 21.9, ranged from 19 to 25) who took introductory psychology class participated in the experiment as a course requirement. They were all native Korean speakers, and they all had normal or corrected normal vision.

Stimuli The primes were 42 nonwords that had the same characteristics to the stimuli used in Experiment 1. That is, all nonwords are supposed to have phonological change. For example, the nonword, "반롱" follows a phonological rule which states that the final consonant of the first syllable is changed to match that of the first consonant of the second syllable. Accordingly, the first character (syllable), "반", of the nonword, "반롱", should be pronounced to /bal/, instead of /ban/, which is default pronunciation in which no phonological change is applied. The target words were the same as used in Experiment 1.

Procedure The procedure was identical to that of Experiment 1.

Results

Mean RTs and standard errors are shown in Figure 2. As in Experiment 1, incorrect

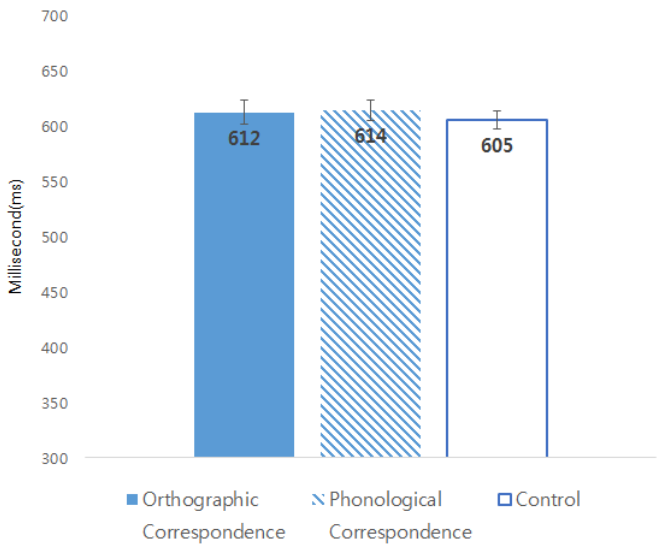

Figure 2. Reaction time (Mean and Standard Errors) across the condition in Experiment 2

responses were excluded from the analysis (6.6%), and the error rates were not statistically different across conditions ($F < 1$). Also, RTs less than 300ms or more than 2000ms were considered outliers and removed from the analysis. In total, 8.6% of data were eliminated form the latency analysis.

An analysis of variance was done using the subjects as a random variable (F_1), and the stimuli as a random variable (F_2). The main effect of the prime and the target relation was not significantly different, showing that reaction times for three conditions did not differ among together ($F_{1(2,58)} = 1.67$, $p > .20$; $F_{2(2,82)} = 0.48$, $p > .49$).

Discussion

The results reported in Experiment 2 showed that the lexical inhibition based on phonological representation found in Experiment 1 did not occur, when the prime stimulus had no lexical status. If the competition occurred at a pre-lexical level, the similar pattern of results to Experiment 1 should be observed in the present experiment. However, we did not get either facilitation or inhibition with respect to the prime and target relation. Based on this result, we can infer that the inhibitory effect of the phonologically related primes observed in Experiment 1 was generated due to lexical competition between the target and competitors activated by the prime word as well as the prime itself. More detailed explanation is discussed in the General Discussion.

General Discussion

The results of the current study can be summarized as follows: 1) Experiment 1 showed that participants responded to a target word more slowly when a prime and a target were phonologically related as compared to when they had no relationship, however, they responded to the target faster when the prime and the target were orthographically related relative to when they were not. 2) The inhibition by the phonological syllable and the facilitation by the orthographic syllable were bigger in the lower-frequency prime condition relative to the higher-frequency prime condition. 3) In Experiment 2, no priming effect was observed in any of the nonword prime conditions.

There are several possible interpretations for these results. First, the lexical inhibition found in the phonologically related condition could be attributed to competitive processes among phonologically-related words at the lexical level (McClelland & Rumelhart, 1981). In other words, the prime word appeared to activate its phonological neighbor words that shared its first syllable, and then the neighboring words

inhibited each other, leading to a delay in target word processing (relative to the processing of a control word). Based on the results, it is tentatively concluded that two-syllable Korean words are processed as a phonological lexical entity, and this entity has inhibitory links to other units in the phonological mental lexicon (Kwon et al., 2006; Kwon, 2009). The phonologically changed word, "근로", for instance, might be processed not as "근로"/Geun.lo/, but as "글로"/Geul.lo/. Then "근로"/Geul.lo/ might inhibit the target word that overlaps the first syllable with the prime.

Similarily, neighbor words activated from the prime could be a source of lexical competition (Segui & Grainger, 1990). For example, the prime could activate its phonologically neighboring words such as "글자"/Geul.ja/, "글감"/Geul.gam/, "글씨"/Geul.ssi/, and so on. Accordingly, because these neighbors inhibit each other, recognition of the target word, "글귀"/Geul.gui/ would be delayed. Segui and Grainger (1990) argued that the inhibitory effect on the target word is a function of the relative word frequencies of primes and targets. When the word frequency of the prime word was lower than that of the target (e.g., char-CHAT), inhibitory effects were observed, whereas no such inhibitory effect was observed when the word frequency of the prime word was higher than that of the target (e.g., chat-CHAR). The results reported in Segui and Grainger (1990) were attributed to a lexical competition process such that during processing of the prime word, the lower frequency prime word allegedly competed with higher frequency candidates, which led to inhibition of the target during the recognition process (Segui & Grainger, 1990). Experiment 1 of the current study also showed that phonological inhibition was greater for low frequency prime words than high frequency ones. In order to recognize low frequency words successfully, other neighbor words (especially higher-frequency words) should be inhibited, which led to greater inhibition in the low-frequency prime condition relative to the high-frequency prime condition. Note that the inhibitory processing should occur based on phonological syllable, not based on orthographic syllable to explain the result shown in Experiment 1. This explanation is consistent with the idea that a visual word form is converted to phonological representation that is used for accessing mental lexicon in Korean visual word recognition (Kwon, 2009; Kwon, Lee, & Nam, 2011; Nam et al., 2001). However, Bae & Yi (2010) suggested an alternative explanation for the inhibitory effect of the phonological syllable. In their study, they posited that lexical access in Korean visual word recognition occurs mainly via orthographic, not phonological, representation. According to their explanation, the word, 글귀,

is not able to get feedforward facilitation from the prime word, 근로, because these two words does not share orthographic syllable. Instead, the first syllable of the target (글) would get inhibition from the first syllable of the prime (근) in the syllabic unit. Accordingly, a target word (e.g., 글귀) is processed slower than a control word (e.g., 백치) when a prime word is a phonologically related word (e.g., 근로).

The finding that faster RT in the orthographically related condition over the control condition might be interpreted as a secondary effect. Other experiments using masked priming tasks with very a short prime duration (i.e., less than 60ms) have shown a similar facilitative effect (Evett & Humphreys, 1981; Ferrand & Grainger, 1992, 1993, 1994; Lukatela & Turvey, 1990; Perfetti & Bell, 1991). This effect has been generally attributed to the activation of orthographic pre-lexical information shared by the prime and target (Lupker & Colombo, 1994). This interpretation suggests that orthographic overlap between the prime and the target can affect processing from the letters to mental lexicon in a bottom-up fashion. For example, Ferrand, Segui, & Grainger (1996) suggested that syllables can influence word recognition in languages that have clear syllable boundaries, such as French and Spanish. Ferrand et al. (1996) reported facilitative effects when the prime and target pair had the same first syllable, implying that syllabic representations are activated at a pre-lexical level. On the other hand, the facilitative effect in the orthographically related condition of the current study may need to be explained differently because we used unmasked prime stimuli. If the facilitative effect of the orthographically related condition was driven by the pre-lexical activation, a facilitative effect should have been observed in Experiment 2 because the prime-target pairs also shared the same first syllable. This logic indicates that phonology-based inhibition and orthography-based facilitation occur at the lexical level, or by a strategic expectation. An alternative explanation for the facilitative priming effect by the orthographically related condition was suggested by Bae & Yi (2010). Bae & Yi suggests that orthographic syllable directly activates lexical items without converting it to phonological syllable. According to their explanation, the facilitative effect by the orthographic syllable occurs based on the spreading activation of lexical entries that share the orthographic syllable with the prime word, which is a more parsimonious explanation because orthographic syllable does not have to be converted to phonological syllable. However, this model cannot explain why Experiment 2 did not report the facilitative effect of the orthographically related nonword prim e condition. If lexical

entries are activated based on orthographic syllable, orthographically related words should be activated based on the nonword prime that shares orthographic representation with a target word. To clarify these issues, further research needs to be done using multiple SOAs.

As introduced earlier, the influence of syllables is prominent in languages that have clear syllabic boundaries (Ferrand et al., 1996; Carreiras et al., 1993, Kwon et al., 2006). As mentioned earlier, syllables have a facilitative effect when the prime and the target share the same first syllable (Ferrand et al., 1996; Kwon et al., 2006). In English, syllabic priming effects have been observed for words with clear syllabic boundaries. Ferrand, Segui, & Humphreys (1997) found a syllabically driven priming effect with words that had clear syllabic boundaries (e.g. balcony). However, no such effect was found with words that had ambiguous syllabic boundaries (e.g. balance). Moreover, inhibitory effects have been found when the first syllable of a word is of a high frequency (Alvarez et al., 2000; 2001; Carreiras et al., 1993; Carreiras & Perea, 2002), which seems to occur due to the lateral inhibition of many competing words sharing the same first syllable. the results of the current study support the idea that a syllable is a crucial unit in visual word processing. One intriguing aspect of our results concerns the different functional roles of phonology and orthography in Korean visual word recognition. Recall that we found that an inhibitory effect occurred when there was phonological first syllable overlap between the prime and the target, whereas a facilitative effect occurred when there was orthographic first syllable overlap. This suggests that the syllabic units generated by different linguistic aspects (orthography vs. phonology) have different functional roles in Korean visual word recognition (Bae & Yi, 2010; Kwon, 2009; Kwon et al., 2006).

Another interesting finding of the present study was the effect of nonword primes. As in Experiment 1, the primes used in Experiment 2 had phonological change. For example, the non-word, "반롱", is an irregular nonword. For this nonword, the pronunciation of the final consonant of the first syllable was changed to the same sound of the initial consonant of the second syllable. Accordingly, the nonword prime would have two different representations (just like the word prime): an orthographic and a phonological one. If this nonword with phonological change was processed like a real word with the phonological change, then the phonologically related condition in Experiment 2 should have created an inhibitory effect. However, neither an inhibitory or facilitative effect was found in Experiment 2, suggesting that there was no competitive processing at the lexical level when nonword primes were used.

Note that it has been found that nonword primes yield facilitative effects in a masked (i.e., unidentifiable prime) visual priming paradigm (e.g. Lukatela, Frost, & Turvey, 1998). Similar results have also been found in a study using Korean visual word (Nam et al., 2001). Nam et al. (2001) showed a facilitative effect in a priming task using Korean pseudo-homophones and nonwords. Nam et al. (2001) had 3 prime-target SOA's (90ms, 120ms, and 1000ms) and found that the form priming effect decreased as the SOA increased. Given that the 150 ms SOA condition used in the current study was longer than the two short SOA conditions of Nam et al.'s (2001), it is possible that any facilitative effect could have decayed (Ferrand & Grainger, 1993; Nam et al., 2001). Therefore, it might be necessary to manipulate SOA in future studies in order to elucidate the role of Korean nonword primes.

Although our study found several interesting results, it has several limitations. First, because we used only one SOA, other mechanisms governing the activation and inhibition of phonological and orthographic information cannot be systematically analyzed. This is because phonological and orthographic information may activate at different rates (Ferrand & Grainger, 1993). Thus, future studies must manipulate SOA to elucidate the roles of phonological and orthographic information in lexical processing of Korean visual word recognition. Another caveat of this study was to use different target words across conditions. Although we thoroughly controlled orthographic characteristics of the target words, it would be better to vary prime words. Future studies might also manipulate syllable length because Korean words with syllable lengths different from the ones used here may have different characteristics (Lee & Gough, 1996). Also, although list order was counterbalanced for the different target conditions, each subject encountered the same prime three times in Experiment 1. It is possible that such repetition might have contaminated the results. Finally, the actual construction of nonword stimuli is another important factor to be considered. Lee and Kim (2003) found that phonological processing was influenced by the ease with which a phonological rule could be applied. Therefore, one must wonder what results would occur if nonword stimuli were used for which phonological rule application was easy. Thoroughly exploring the aforementioned variables in future studies would greatly clarify our understanding of Korean visual word recognition.

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1 차원고접수 : 2015. 01. 22
수정원고접수 : 2015. 07. 28
최종게재결정 : 2015. 07. 29

한국심리학회지 : 인지 및 생물
The Korean Journal of Cognitive and Biological Psychology
2015, Vol. 27, No. 3, 561-581

한국어 시각 단어 지각시 나타나는 음운 정보의 어휘적 억제

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본 연구에서는 점화 어휘 판단 과제를 사용한 두 가지 실험을 통해, 한국어의 시각 단어 지각시 표기 음절과 음운 음절의 역할을 알아보고자 하였다. 점화 자극과 목표 자극의 첫 음절의 관계를 조작하였는데, 표기 정보가 일치하는 조건, 음운 정보가 일치하는 조건, 그리고 두 정보 모두 일치하지 않는 통제 조건이 사용되었다. 실험 1에서는 음운 변화를 일으키는 점화 단어가 사용되었을 때, 점화 자극과 목표 자극 사이의 음운적 유사성에 기인한 어휘 경쟁 효과가 나타나는지 알아보았고, 또한 이러한 점화 효과가 점화 자극의 어휘 빈도에 따라 달라질 수 있는지를 함께 알아보았다. 실험 2에서는 비단어 점화 자극을 사용하여 실험 1에서 나타난 효과가 단어 재인의 어떤 단계에서 일어난 것인지 규명하였다. 실험 결과, 실험 1에서는 음운 일치 조건이 통제 조건에 비해 반응 시간이 더 느렸던 반면, 철자 일치 조건은 통제 조건에 비해 빠른 반응 시간을 보였다. 그리고 이러한 경향성은 저빈도 단어가 점화 자극으로 사용되었을 때 더 커졌다. 그러나 실험 2에서와 같이 비단어로 구성된 음운 변화 자극이 점화어로 사용되었을 경우는, 음운, 표기, 통제 조건 사이에 반응 시간의 차이가 없었다. 이는 한국어의 시각 단어 재인시 억제적 점화 효과가 어휘 전처리 과정에서 일어나는 것이 아니라, 어휘적 수준 하에서 점화 자극과 목표 단어 간 어휘적 경쟁에 의해 일어난다는 점을 시사한다.

주제어 : 어휘적 경쟁, 음절 점화, 음운 변화

Appendix

Experiment 1				Experiment 2	
Prime	Target			Prime	Target
High Freq.	Orthographic condition	phonological condition	control condition	Nonword	
반란	반박	발급	증발	반롱	
근로	근저	글귀	백치	근럭	
언론	언변	얼개	과식	언린	
연락	연봉	열대	보답	연릭	
권력	권사	궐기	변칙	권라	
신라	신생	실기	도량	신루	
논란	논박	놀람	하례	논링	
난로	난무	날밤	섬모	난링	
전략	전조	절개	급소	전릭	
진리	진급	질책	두레	진링	
탄력	탄핵	탈주	침략	탄링	
혼란	혼담	혼수	우박	혼룽	
독립	독촉	동심	증기	독룽	
국립	국법	궁합	변질	국렉	
막내	막후	망발	방심	막니	
속물	속칭	송사	둔갑	속밍	
격려	격리	경건	편중	격를	
직무	직속	징후	소집	직맨	
법률	법제	범법	출감	법릴	The same with the target of Experiment 1
섭리	섭생	섬멸	해괴	섭랄	
업무	업보	엄벌	족쇄	업뭉	
Low Freq.					
연루	연꽃	열등	형부	연를	
난립	난투	날숨	만학	난루	
난류	난색	날품	귀한	난랙	
산란	산파	살포	은닉	산룽	
만료	만삭	말세	화폭	만르	
찬란	찬반	찰흙	염산	찬룽	
한려	한담	할거	망평	한료	
격렬	격전	경마	군살	격릴	
녹말	녹두	농간	결전	녹밀	
박멸	박쥐	방귀	여분	박밍	
복록	복통	봉건	엄벌	복라	
석면	석조	성년	공시	석맨	
숙면	숙박	숭늉	당쟁	숙뭉	
악력	악공	앙탈	갈채	악릴	
역모	역습	영지	경합	역멸	
익년	익살	잉어	치부	익눙	
작명	작두	장끼	낙방	작밀	
합류	합병	함양	접대	합린	
삽날	삽질	삼복	책동	삽눌	
섭렵	섭생	섬세	대납	섭릭	
집례	집정	짐차	접견	집리	