Korean L2 Speakers' Orthography and Phonological Representations in English

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We investigated the possibility of whether there is a post-vocalic 'r' in phonological representations of Korean L2 English speakers and the extent to which they exploit their knowledge of mapping graphemes onto phonemes within each correspondence between orthography and phonemes. First, the results obtained in the pseudohomophone task showed that R-items were responded to with higher accuracy and shorter RT than Non-R items. It suggests that there is no post-vocalic 'r' in phonological representations of Korean L2 speakers unlike Australian native English speakers and that Korean L2 learners are truly non-rhotic speakers. Another striking finding is that accuracy and RT for visual lexical access varied depending on the transparency between orthography and its corresponding phonemes. This indicates that Korean L2 speakers' knowledge about the association of graphemes and phonemes varies depending on each type of correspondence between spellings and phonemes. Finally, it was found that the frequency of the base words also affected the retrieval of words along with the orthographic depth in grapheme-to-phoneme correspondences.

Key Words: English orthography, grapheme-to-phoneme, Korean L2 speakers, orthographic depth

Ⅰ. INTRODUCTION

1. Orthography and Phonology

Past decades of research has increasingly shown that orthography not only influences phonological representation but affects speech perception and production (production: Damian & Bowers, 2003; Lupker, 1982; perception: Seidenberg & Tanenhaus, 1979; Ziegler, Petrova, & Ferrand, 2008). For instance, Lupker's (1982) picture-naming task showed the result that pictures were named more rapidly when distracters had the same spelling as the name of the picture (e.g., the picture of a 'plane' with a distracter of 'cane') than when they had the similar pronunciation (e.g., the picture of a 'plane' with a distracter of 'brain'). Since the current study is mainly concerned with the effect of orthography on word recognition, literature concerning its influence on perception will be briefly reviewed.

A pioneering rhyming task by Seidenberg and Tanenhaus (1979) and Tanenhaus, Flanigan, and Seidenberg (1980) found that rhyming pairs with similar orthography (e.g., TURN, BURN) were responded faster than those with different one (e.g., TURN, LEARN). Furthermore, Taft and Hambly's (1985) syllable monitoring task obtained a very interesting finding that orthographically defined first syllables[1] (e.g., GOS in GOSSIP) were recognized more rapidly and accurately than phonological first syllables (e.g., GOS in GOSPEL). This was interpreted to suggest that orthographically defined syllables have psychological reality in the lexicon and that they influence the phonological representation. However, other research failed to find significant effects of orthography on word recognition (Slowiaczek, Soltano, Wieting, & Bishop, 2003; Taft, Castles, Davis, Lazendie, & Nguyen-Hoan, 2008). Thus, a question has not been satisfactorily answered as to whether and to what extent the spelling of words influences speech processing like production and perception.

Two possible explanations have been proposed concerning the visual word recognition, focusing on the relation between orthography and phonological representation. When the spellings of words are presented to speakers, how can they be recognized as words by matching them in the lexicon? The first position is that graphemes or spellings are coded into phonological representation again, which makes it access to mental lexicon (Liberman, Liberman, Mattingly, & Shankweiler, 1980). That is, 'p' in the spelling 'pit' is recoded into /p/ in phonological representation, which serves access input to its corresponding word in the lexicon. This account is called 'prelexical approach'. In languages such as Serbo-Croatian, German, or Korean where each letter denotes only one phoneme and one phoneme is represented mostly by one grapheme, the relation between the two is straightforward and relatively transparent. Liberman et al. (1980) and Katz and Feldman (1981) refer to such a system as "a shallow orthography". Frost (1989) claims that 'prelexical' phonological representations fit into a shallow orthography. In contrast, the second explanation is that lexical access is directly based on orthography and phonological representations are derived after lexical access, which is called 'post-lexical approach'.[2] In languages such as English and Hebrew where there

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[1] According to Taft's (1979) proposal, orthographically defined first syllable consists of onset consonants, nucleus vowels and all the consonants following the nucleus. For example, the first syllable of GOSPEL is GOSP, not GO or GOS.

[2] Note that the distinction between 'pre-lexical' and 'post-lexical' here is different from that between 'lexical phonological' and 'post-lexical phonetic' traditionally used in lexical phonology. By 'pre-lexical', we mean the coding of graphemes into phonological representations occurs "before" lexical access is performed while 'post-lexical' means that phonological representations are derived "after" lexical access is completed.

are many-to-many correspondences between spellings and phonemes, lexical access is direct from orthography. That is, the word 'rough' is recognized from the visual stimuli 'rough', and phonological representation /rʌf/ is derived later. Such a post-lexical approach is suitable for 'a deep orthography' language such as English. However, Seidenberg (1985) argued that such an 'orthographic depth' effect emerges only in the processing of high-frequency words except for low-frequency words. That is, he proposed that phonological representations of frequent words are derived post-lexically after lexical access is accomplished. The present study will investigate whether and to what extent Korean L2 English speakers process visual stimuli based on orthography and recognize words.

Concerning the relation of spelling and phonological representations, a conflicting phenomenon comes from the pronunciation of 'r' in American English and British English. As is known, spelling 'r' is not pronounced following a vowel in British English on the surface, whereas it is in American English. Taft (2006) conducted an interesting processing experiment to see if /r/ is contained in the phonological representations of the apparent non-rhotic speakers. Native speakers of Australian English were asked to see the pseudohomophone such as 'katt' (cart) and decide if it is pronounced like a real word. His pseudohomophone task showed that participants responded to visual stimuli containing orthography with(out) a post-vocalic 'r' (e.g., 'cawn, forl, …') less accurately than those with non-r orthography (e.g., 'soke, troo, ...'). The result was interpreted to suggest that since the phonological representation for 'cawn' does not match the one for /kɔrn/ 'corn', non-rhotic speakers might suffer difficulty recognizing and accessing the appropriate word. That is, it indicates that 'r' following a vowel is embedded in phonological representation even though it is represented in orthography and not pronounced on the surface by non-rhotic speakers.

2. Research Questions

Building on and extending Taft's (2006) study for L1 non-rhotic English speakers, the current study seeks to address two questions as regards the relation between orthography and phonological representations for L2 speakers.

The first to be explored is whether Korean L2 English speakers have an underlying post-vocalic /r/ in phonological representations. Like British or Australian English speakers, low-level Korean L2 speakers usually do not pronounce a post-vocalic /r/ in r-colored words such as 'car, large, dark, jerk, etc'. If that is the case, an interesting question arises as to whether Korean non-rhotic speakers have an underlying post-vocalic 'r' in the phonological representation. That is, are they latently rhotic 'r' speakers like Australian English speakers due to the orthographically influenced phonological representations even though a post-vocalic /r/ is not realized on the surface? To testify to the potential existence of /r/ in the mental lexicon of Korean L2 speakers, Taft's pseudohomophone task was conducted with more ample data. There can be two possible expectations. First, if there is an underlying /r/ in the phonological representation for r-colored words such as 'dart', it should be difficult to match the visual stimulus 'bock' with its homophone 'bark'. It is due to the psycholinguistic process whereby after subjects apply the grapheme-phoneme conversion rule (ock => /ɑk/), they would attempt to match its phonological representation output (/bɑk/) with 'bark'. Thus, if there is a post-vocalic /r/ in the word representation, processing would be hampered. As a result, accuracy is expected to be relatively lower and reaction time also would be slower than the processing of lexical items which do not contain /r/ both in the orthography and underlying representation. Second, a totally opposite result might come about. In accordance to the same reasoning, it is likely that if there is no post-vocalic /r/ in the phonological representations, it would not be hard to match the visual stimuli involving 'r' with the underlying form without 'r' in the lexicon. Presumably because of lack of processing burden, accuracy would be not be lower or reaction time would not be longer than non-R items which do not relate to a post-vocalic 'r'. This case might be that Korean L2 speakers do not pronounce a post-vocalic 'r' and have an underlying phonological representation without specification of 'r'.

Another interesting question to probe is whether English orthography influences phonological representations as regards correspondences between graphemes and phonemes for Korean L2 speakers. As far as we know, the current study might be the first attempt to reveal different strengths of association between a grapheme and an underlying phoneme. For example, it might be comparatively easy to retrieve a phoneme /k/ from the orthography 'c' or 'k' (e.g., thinc, kar). However, the matching of the spelling 'eau' (e.g., theau) onto the underlying phoneme /o/ might be processed in a different degree. We will test the potential differences in the strengths of connection between graphemes and phonemes through processing experiment where accuracy and reaction times are measured. Thus this study will shed light on the nature of correspondences between a visual stimulus and phonological representations for L2 speakers. It is expected that if orthography were to exert an influence on the mapping of the underlying phonemes with different degrees for each correspondence, accuracy and reaction time would differ in pseudohomophone task, depending on the individual relation between graphemes and phonemes.

Ⅱ. METHODS OF PROCESSING EXPERIMENT

1. Subjects

Twenty Korean L2 speakers of English participated in the psycholinguistic experiment. All participants were undergraduate students and their major or minor was English. Eight were male and twelve female. Their average age was 23, ranging from 21 to 27. The average length of formal English education was 11 years, ranging from 6 to 16 years. Their self-rating English proficiency level was 5.1 on the average out of 10 scales, ranging from 3 to 7. They seem to have evaluated their proficiency either as low- or intermediate-level.[3] Their official TOEIC score was on the average 606 points for the paper test, ranging from 400 to 880.[4] Korean speakers' English learning background is summarized in Table 1.

TABLE 1

Korean Speakers' English Learning Background

	No.	Mean	Min	Max	SD
Age	20	23	21	27	1.6
Length of Eng. Study	20	11	6	16	2.8
Self-rating proficiency	20	5.1	3	7	1.2
TOEIC score	20	606	400	880	143

2. Stimuli

Similarly to Taft's (2006) design, stimuli consisted of three groups of nonwords: (i) R items, (ii) Non-R items, and (iii) Nonword fillers as exemplified in (1). 24 R items had the same pronunciations as pseudohomophonic real words depending on the availability

[3] Since highly proficient learners are likely to pronounce a post-vocalic /r/ on the surface and thus to have /r/ in phonological representations like native speakers of English, they were not recruited from the pool of subjects in the current study. Furthermore, to compare with non-rhotic /r/ speakers like British or Australian speakers, L2 learners of low- or intermediate-level in English seem to be more appropriate in view of the purpose of this study.

[4] As suggested by an anonymous reviewer, it might be convenient to judge whether the subjects are rhotic speakers by asking them to pronounce words containing a post-vocalic 'r', which I agree with. Actually some participants pronounced it whereas others did not. However, the purpose of the current study is to examine whether Korean learners are latently rhotic or not by confirming the processing patterns of these words and attempting to reveal its status in the mental lexicon rather than to investigate their production patterns. Nonetheless, since both the production and the processing experiments contribute to drawing a comprehensive picture, they might await future research.

of pronunciation of a post-vocalic /r/. For instance, 'cawn' is homophonic with 'corn' in case that 'r' in the base word 'corn' is pronounced, and 'forl' is homophonic with 'fall' in case that 'r' in the stimulus is not pronounced. That is, each R item had its corresponding base word, i.e., a real word. In order to extend the data, 15 R items were added to the stimuli extracted from the list employed in Taft's study as in (1a).

Next, 43 Non-R items also had homophonic real words represented in the parentheses as illustrated in (1b). For example, 'sneaz' is homophonic with the real base word 'sneeze' when 'ea' represented in the orthography is pronounced as /i/. However, Non-R items did not contain a post-vocalic r. 9 Non-R items were extracted from the list exploited in Taft (2006), and we added 34 items to elicit generalization. There are two reasons why Non-R items were used in the current experiment. First, such items were designed as control items to compare with the processing of R items, i.e., to see whether there is a post-vocalic /r/ in the phonological representations for Korean L2 speakers. Another reason was to test to find out whether Korean L2 speakers had knowledge about mapping from grapheme to phoneme in English except for a post-vocalic 'r'. Thus Non-R nonword items were created to contain spellings (or graphemes) which represent seven vowel phonemes such as /i, e, ɛ, u, o, ɔ, aɪ/ and seven consonant phonemes such as /k, g, f, tʃ, dʒ, w, ʃ/. Specifically, Non-R items included spellings {ea, ee, e} for their corresponding phoneme /i/ (e.g., *sneaz*), {ai, a, ai} for /e/ (e.g., *laik*), {e} for /ɛ/ (e.g., *ges*), {oo, ew} for /u/ (e.g., *froot*), {eau, oa, o} for /o/ (e.g., *bloa*), {aw} for /ɔ/ (e.g., *tawk*), {y, ei} for /aɪ/ (e.g., *lyne*), {c, k} for /k/, {g, gh} for /g/, {f, ph} for /f/, {tch, ch} for /tʃ/, {w} for /w/, and {sh, sch} for /ʃ/. As shown in (1b), each of Non-R item was designed to be homophonic with a real English word (e.g., 'sneaz' ≈ 'sneez' /sniz/).

The 35 nonword filler items were randomly interspersed with 24 R items and 43 Non-R items. These nonwords were not homophonic with any of real English words (e.g., *baft, bish, grube*, etc).

(1) Sample stimuli (See Appendix for the full list)

a. R items	b. Non-R items	c. Fillers
cawn (corn)	sneaz (sneeze)	baft
wod (word)	neece (niece)	bish
cot (cart)	laik (lake)	grube

Most of the stimuli were monosyllabic except for 6 disyllabic ones. In total, 102 items were presented in lowercase on the screen of the computer in a random order to each subject through the software E-Prime Professional 2.0.

3. Procedure

To obtain subjects' English learning background information, a survey questionnaire was given to them before the main experiment started. After completing the questionnaire, five test visual stimuli were presented to the participants. Next, main processing experiment proceeded in two blocks, basically following Taft's (2006) pseudohomophone task. Note that in the main experiment blocks, only nonce words (i.e., pseudohomophones) were presented and the real base words were not shown on the computer screen. In block I, each visual stimulus was presented on the computer screen to each participant and was asked to say the stimulus to him/herself silently, but not to read aloud. They were told to decide if its pronunciation is identical to the one of a real English word. Then, they had to press 1 on the keyboard if it is, but 2 if it is not. This challenging task is designed to see if the underlying form of /r/ exists in the mental lexicon.

Following the completion of the pseudohomophone task in block I, the identical stimuli were presented to the subjects again and they were asked to perform the same homophone task after they read the stimuli aloud and listen carefully to their pronunciation. They were told to press the button '1' on the keyboard if its pronunciation is identical to a real English word or '2' if it is not.

Displaying the stimuli and randomizing their order was controlled by E-Prime 2.0 Professional software. A pause of 2000 ms timeout after stimulus offset was placed with a word "Next" on the screen when subjects responded with a keyboard. On average, it took about 20 minutes to complete the entire experiment. All the responses, including longer than 2000 ms, were collected for data analysis since it took comparatively long to perform in Read aloud condition.

In order to see whether R-items are processed with more difficulty than non-R items or nonwords and whether orthographic influences on phonological representations vary depending on the correspondence between specific graphemes and phonemes, accuracy and reaction times were measured using E-Prime. These two dependent variables were evaluated within each block. Furthermore, since they were obtained within each subject, they were submitted to a one-way or two-way repeated-measures ANOVA.

Three factors were statistically investigated: (i) experimental type (Silent vs. Aloud), (ii) stimuli condition (R items vs. Non-R items vs. Nonword), and (iii) grapheme-phoneme condition. In order to see the interaction of experimental type and stimuli condition, a two-way repeated-measures ANOVA was performed by PASW(SPSS) Statistics 18. The results of analyses are depicted as significant if $p<0.05$, and highly significant if $p<0.01$.

Ⅲ. RESULTS OF PROCESSING EXPERIMENT

Table 2 shows the mean accuracy of response by experimental type and stimuli condition. A 2-way repeated-measures ANOVA revealed that there were main effects of Experiment Type ($F(1,19)=10.5$, $p<.01$) and of Stimuli Condition ($F(2,38)=36.1$, $p<.001$). Interaction of the two factors reached significance ($F(2,38)=3.38$, $p=.04$).

First, these results showed that accuracy was higher when subject read the stimuli aloud than when they said to themselves silently. They indicate that speaker's own on-line pronunciation is conducive to mapping it onto the lexical item in the mental lexicon. It might be the case that it would have been easier to retrieve underlying representations fit for the orthography when the stimuli were read loudly. Second, as illustrated in Table 2, it is surprising that even in Silent condition, accuracy was higher for R items than for Non-R items (82.6% vs. 72.9%). This finding, however, is not consistent with those obtained for Australian speakers (Taft, 2006). His study found that accuracy for R-items was lower than for Non-R items, indicating that they had an underlying post-vocalic 'r' represented in the orthography even though they do not pronounce it on the surface. Furthermore, post-hoc pairwise comparison (LSD) showed that, putting together the results in both conditions, accuracy was significantly higher for R items than for Non-R items (82% vs. 74%, $p<0.05$). This finding suggests that non-rhotic Korean speakers have not had difficulty in mapping the visual stimuli words onto the base words because there was no 'r' in their phonological representations. Such an interesting finding might be due to the fact that the pseudohomophones of R-items involve only absence/presence of 'r', while the pseudohomophones of Non-R items involve processing of many types of grapheme-phoneme conversions (i.e., six vowels and six consonants). That is why participants might have suffered more processing load for Non-R items than for R-items. Finally, it makes sense that accuracy was lowest for filler nonwords. Since those words did not contain a post-vocalic 'r' and did not have base words as real words, it is highly likely that subjects suffered greatest difficulty in mapping such words in the lexicon. Of course, it might be attributable to the fact that there are no phonological representations for these stimuli.

TABLE 2

Mean Percentage of Accuracy by Experimental Type and Stimuli Condition

Expe. Type	Stimuli condition (% correct, SD)			
	R item	**Non-R item**	**Nonword**	**Total**
Silent	82.6 (11.2)	72.9 (9.7)	41.3 (15.6)	65.6
Aloud	81.5 (13.7)	76.5 (8)	48.2 (20)	68.7
	F(1,19)=0.3, p>0.05	F(1,19)=5.66, p=0.02*	F(1,19)=6.77, p=0.01*	
Total	82	74	44.7	

Next, as planned in the current study, reaction times were analyzed to see if accuracy results are endorsed. Reaction times for analysis were averaged for the correctly replied items. As shown in Table 3, we found the similar results to accuracy ones. A two-way repeated-measures ANOVA exhibited that a main effect of Stimuli Condition was found ($F(2,38)=46.5$, $p<.001$), whereas a main effect of Experimental Type was not (Type, $F(1,19)=2.36$, $p>.05$). Interaction between the two did not approach significance ($F(2,38)=.46$, $p>.05$). One of the most striking findings is that it took much lesser time to response to R items than Non-R items in both the experimental types (1.4 sec. vs. 1.7 sec.). This suggests that Korean subjects did not substantially have trouble retrieving the underlying representations for R-items presumably because the absence/presence of a post-vocalic 'r' in the orthography directly reflects phonological representations in the lexicon. Hence it is probable that there is no post-vocalic /r/ in the underlying representations for Korean speakers who do not pronounce it. This result corroborates the findings for accuracy. Furthermore, the finding that it took longest time to respond to filler nonwords suggests that since these words do not have lexical representations, subject suffered from mapping orthographically nonwords onto the existing words in their lexicon. The only difference between Silent Type and Aloud Type was obtained for R item condition: unlike the accuracy result, it took longer to process R items in Aloud Type than in Silent Type. This is interesting in that even in more difficult experimental type (i.e., Silent Type), subjects mapped the absence/presence of a post-vocalic 'r' onto the lexical words rather quickly.

TABLE 3
Mean Reaction Time by Experimental Type and Stimuli Condition

Expe. Type	Stimuli condition (ms., SD)			
	R item	Non-R item	Nonword	Total
Silent	1378 (492)	1705 (495)	2657(975)	1913
Aloud	1559 (387)	1790 (469)	2779 (992)	2043
	F(1,19)=5.18, p=.03*	F(1,19)=1.04, p>0.05	F(1,19)=0.84 p>0.05	
Total	1469	1747	2718	

In summary, putting together the results of accuracy and reaction time, regardless of whether the stimuli were presented either in orthography in Silence condition or in orthography with speakers' own utterances, R items were responded more accurately and rapidly than Non-R items. Such an interesting finding can be interpreted to suggest that there is no post-vocalic 'r' in the phonological representations in the mental lexicon of Korean L2 English speakers.

Another major question to be addressed in the current study is whether the correspondence relations between spellings and underlying representations exert a different level of influence on the processing, i.e., mapping the orthography onto the words in the lexicon. Thus only Non-R items were analyzed, whereas R items and Nonword fillers were removed from consideration. As is known, the relation between orthography and underlying phonemes in English is not transparent but displays many-to-many correspondences. Thus four items such as 'ges', 'qween', 'qwick', and 'qwit' were removed from the analysis because 'ges' is the only one item with base word 'guess', and in the other three items, spelling 'w' constantly reflects a phoneme 'w'.

Table 4 shows mean accuracy and RT by each type of correspondence between spelling and UR in both the experimental conditions. For one thing, accuracy and RT varied depending on the type of underlying phonemes as will be discussed later (Table 5 and 6). Second, accuracy and RT differed in accordance with each spelling type (Accuracy, $F(24,38)=3$, $p<.05$; RT, $F(24,38)=2.7$, $p<.05$). For example, accuracy was higher and reaction time was faster when a stimulus containing 'ee' was given than when the stimuli containing 'ea' or 'e' was presented to judge the homophones with the identical phoneme /i/. Third, it was observed that the higher accuracy, the shorter reaction time.

TABLE 4

Mean Accuracy and RT by Correspondence between Orthography and Underlying Phonemes

Orth	Ex	UR	Acc(%)	RT(ms.)	Orth	Ex	UR	Acc(%)	RT(ms.)
ea	*sneaz*	/i/	80	2191	c	*thinc*	/k/	75	2003
ee	*neece*		87.5	1834	k	*kar*		88.7	1325
e	*beme*		40	2463					
ai	*laik*	/e/	91.2	1582	g	*gost*	/g/	97.5	1047
a	*gane*		92.5	1820	gh	*egh*		38.7	2203
ay	*naim*		72.5	2088					
oo	*froo*	/u/	89.1	1558	ph	*rouph*	/f/	91.5	1696
ew	*shew*		55	2509	f	*fone*		72.5	1594
eau	*theau*	/o/	25	2599	tch	*nachure*	/tʃ/	47.5	2763
oa	*bloa*		50	2144	ch	*wach*		93.7	1907
o	*soke*		67.5	2263					
aw	*tawk*	/ɔ/	55.8	2323	dg	*madgic*	/dʒ/	61.6	2750
y	*lyne*	/aɪ/	82.5	1780	sh	*tenshion*	/ʃ/	95	1776
ei	*keight*		85	2240	sch	*schure*		42.5	3041

Table 5 shows accuracy and reaction times for Non-R item words with various spellings and their corresponding underlying phonemes when the visual stimuli were presented in Silent condition. A one-way repeated-measures ANOVA revealed that there was a significant effect of each correspondence between orthography and underlying phonemes on the accuracy ($F(11,209)=6.62$, $p<.001$). Furthermore, its main effect on RT was also highly significant ($F(11,165)=5.83$, $p<.001$). These results indicate that certain spellings (or orthography) were mapped onto their corresponding underlying phonemes more accurately and rapidly than others. That is, it might be the case that the strength of associations between orthography and underlying phonemes in the L2 speakers' mental lexicon or capacity of retrieval of underlying phonemes from the visual stimuli might vary.

Looking in more detail at the stimuli with vowels, as illustrated in Table 5, the visual stimuli such as 'laik, gane, naim' were presented, accuracy of response was highest (86%) and RT was also second fastest (1753 ms) among the vowel types. It seems that the retrieval of an underlying phoneme /e/ from the spellings such as 'ai, a, ay' is processed rather easily and quickly. Moreover, the visual stimuli such as 'froot, shew' were responded with comparatively high accuracy and rapidity (73%, 1512 ms). It is likely that spellings such as 'oo, ew' have been mapped onto the underlying phoneme /u/ rather efficiently. On the other hand, when the visual stimuli such as 'theau, bloas, soke' were presented, accuracy was comparatively low (47%) and RT was long, compared with the stimuli containing other vowels.

Let us now turn to processing regarding the correspondences between consonant spellings and their underlying phonemes. As shown in Table 5, items with spellings such as ‘c, k’ and ‘ph, f’ (e.g., *thinc, kar, rouph, fone*) were processed most accurately (83%) and comparatively rapidly (1352 ms for ‘c, k’ and 1528 ms for ‘ph, f’). This suggests that these spellings were mapped onto underlying phonemes such as /k/ or /f/ more accurately and relatively efficiently than the others. Interestingly, accuracy was lowest for items such as ‘gost, egh’ even though processing speed was fastest (1309 ms). Additionally, accuracy was also high when the visual stimuli such as ‘nachure, wach’ and ‘tenshion, schure’ were presented (respectively, 78% and 75%). It is presumably because the correspondence between the spellings and their phonemes are rather transparent, not opaque (e.g., ‘tch, ch’ => /tʃ/, ‘sh, sch’ => /ʃ/).

TABLE 5

Mean Accuracy and RT by Correspondence
between Orthography and Underlying Phonemes in Silent Condition

Orthography	Sample Non-R words	Underlying phonemes	Accuracy (%)	RT (ms.)
ea, ee, e	*sneaz, neece, beme*	/i/	66	2136
ai, a, ay	*laik, gane, naim*	/e/	86	1753
oo, ew	*froot, shew*	/u/	73	1512
eau, oa, o	*theau, bloa, soke*	/o/	47	2160
aw	*tawk, brawd*	/ɔ/	49	2401
y, ei	*lyne, keight*	/aɪ/	81	1834
c, k	*thinc, kar*	/k/	83	1352
g, gh	*gost, egh*	/g/	58	1309
ph, f	*rouph, fone*	/f/	83	1528
tch, ch	*nachure, wach*	/tʃ/	78	2108
dg	*madgic, siedge*	/dʒ/	63	2450
sh, sch	*tenshion, schure*	/ʃ/	75	1871

Close scrutiny of our results reveals that visual items containing consonants were responded more accurately than those containing vowels as clearly depicted in Figure 1 (Consonant:Vowel=73.7%:67.5%, $F(1,19)=7.12$, $p=.01$). Furthermore, the former was processed more rapidly than the latter as shown in Figure 2 (Consonant:Vowel=1690 ms: 1866 ms, $F(1,19)=4.68$, $p=.04$). This finding suggests that when the visual words are presented to Korean L2 English learners, consonantal phonemes are retrieved (or mapped) more efficiently than vocalic phonemes. Such differences might stem from the fact that correspondences between spellings and the phonemes are more complicated or opaque for vowels than for consonants, considering the visual stimuli used in the current study. Table 5 shows that there are three to one correspondences between vowel spellings and their phonemes such as /i, e, u, o/ except for /ɔ/ and /ɪ/, whereas there are two-to-one correspondences between consonant spellings and their phonemes such as /k, g, f, tʃ, ʃ/.

FIGURE 1

Accuracy by Phonemes

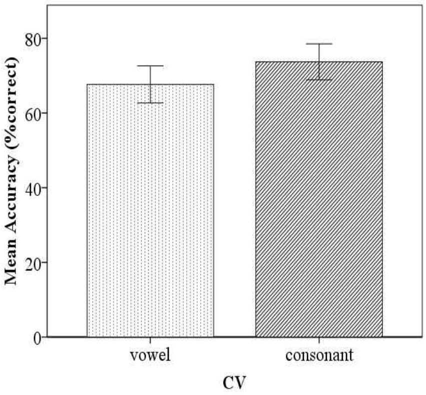
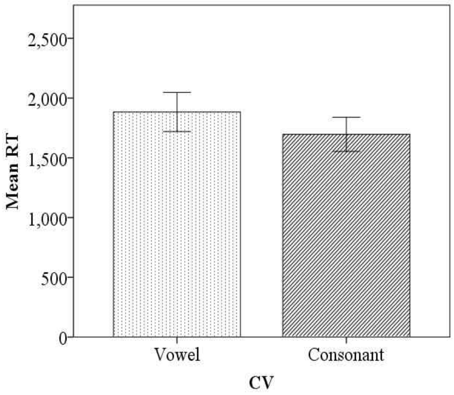


FIGURE 2

RT by Phonemes



In summary, when the visual stimuli were presented in Silent condition, the accuracy and speed of processing consonantal and vocalic orthography significantly differed. Furthermore, it varied across each correspondence between spellings and underlying phonemes.

Next, we look into whether such different processing, i.e., mapping each type of spelling onto the underlying phonemes emerges when the visual stimuli were read aloud. In this condition, subjects read the visual stimuli aloud and could hear their own pronunciations. Thus they could more easily map their pronunciations onto the base words in their mental lexicon. Table 6 shows mean accuracy and RT by correspondence between spellings and their underlying phonemes in Aloud condition. A one-way repeated-measures ANOVA exhibited that there was a main effect of spelling-phoneme relation on accuracy ($F(11,209)=7.74$, $p<.001$) and its main effect on RT also reached significance ($F(11,187)=4.08$, $p<.001$). These findings are consistent with those obtained in the Silent condition, indicating that mapping graphemes onto phonemes differs, depending on each correspondence type for Korean L2 English speakers. Similar to the

Silent condition, accuracy was comparatively higher and RT was shorter when the visual graphemes representing the underlying phonemes such as /e, u, aɪ/ were read aloud than the other vowel graphemes were presented as is shown in Table 6 (Accuracy: 87%, 87%, 85%; RT: 1617 ms, 1787 ms, 1944 ms). Similar to the findings in Silent condition, the visual stimuli such as 'theau, bloa, soke' and 'tawk, brawd' were responded with least accuracy and longest RT. This suggests that subjects had difficulty in mapping the spellings such as 'eau, oa, o' and 'aw' onto the phonemes such as /o/ and /ɔ/.

Additionally, visual stimuli with consonant graphemes representing phonemes /k, f, ʃ/ were responded with comparatively higher accuracy and more rapidity as shown in Table 6 (Accuracy: 85%, 86%, 80%; RT: 1484 ms, 1671 ms, 1990 ms). These results are similar to those obtained in Silent condition. They indicate that grapheme-to-phoneme relations for such cases are rather transparent for Korean L2 speakers. However, similar to findings in Silent condition, it seems that they had trouble retrieving the underlying phonemes such as /g/ and /dʒ/ from the spellings such as 'g, gh' and 'dg'.

TABLE 6

Mean Accuracy and RT by Correspondence between Orthography and Underlying Phonemes in Aloud Condition

Orthography	**Sample Non-R words**	**Underlying phonemes**	**Accuracy (%)**	**RT (ms.)**
ea, ee, e	*sneaz, neece, beme*	/i/	71	1915
ai, a, ay	*laik, gane, naim*	/e/	87	1617
oo, ew	*froot, shew*	/u/	87	1787
eau, oa, o	*theau, bloa, soke*	/o/	48	2009
aw	*tawk, brawd*	/ɔ/	61	2507
y, ei	*lyne, keight*	/aɪ/	85	1944
c, k	*thinc, kar*	/k/	85	1484
g, gh	*gost, egh*	/g/	58	2697
ph, f	*rouph, fone*	/f/	86	1671
tch, ch	*nachure, wach*	/tʃ/	78	1955
dg	*madgic, siedge*	/dʒ/	59	2370
sh, sch	*tenshion, schure*	/ʃ/	80	1990

However, unlike the results of Silent condition, visual items containing consonantal target graphemes were responded with almost the same accuracy as those containing vowel graphemes (Consonant:Vowel=74.8%:73.7%, $F(1,19)=0.17$, $p>.05$). Additionally, there was no significant difference in RT as well (Consonant:Vowel=1803 ms: 1895 ms, F(1,19)=1.11, p>.05).

Finally, we examined whether word length affects the processing of mapping the visual stimuli onto the base words. As illustrated in Table 7, di-syllabic visual words (e.g., *tenshion*) were responded with at least 20% higher accuracy than mono-syllabic stimuli (e.g., *laik*) in both Silent and Aloud conditions (Silent, F(1,18)=71.2, p<.001; Aloud, F(1,18)=75, p<.001). This finding can be interpreted to suggest that longer visual stimuli are more accurately mapped onto the base word presumably because more information can be available with respect to grapheme-phoneme correspondence. However, there was no effect of word length in RT (Silent, F(1,18)=0.64, p>.05; Aloud, F(1,18)=1.86, p>.05). Or as suggested by an anonymous reviewer, it might be due to the fact that di-syllabic words such as 'opher, nachure, madgic, siedge, tenshion' contain the spellings like 'ch, dg, sh' which seems to facilitate the retrieval or matching of their corresponding phonemes /tʃ, dʒ, ʃ/ comparatively easily.

TABLE 7

Mean Percentage of Accuracy by Experimental Type and Word Length

Expe. Type	Word length (% correct, SD) 1 syllable (e.g., *sneaz*)	2 syllables (e.g., *nachure*)	Total
Silent	62.9 (4.1)	89.1 (13.4)	76
Aloud	66.5 (6.5)	94.9 (8.2)	80.7

In summary, the current study obtained three remarkable findings concerning Korean L2 speakers' visual lexical access based on orthography and phonological representations. First, it was found that R-items were responded with higher accuracy and shorter RT than Non-R items. Another striking finding is that accuracy and RT for visual lexical access varied depending on the transparency between spelling (or orthography) and its corresponding phoneme. Finally, it was found that longer visual stimuli were mapped onto the base words with higher accuracy.

Ⅳ. DISCUSSION

1. Are Korean L2 Speakers Truly Non-rhotic Speakers?

We investigated whether Korean L2 English learners of low- or intermediate level have a post-vocalic 'r' in their phonological representations in the lexicon. Taft's (2006) study suggests that Australian English speakers are latently rhotic even though they do not pronounce a post-vocalic 'r' like British English speakers. As mentioned earlier, Taft showed that R-items (e.g., 'cawn') were responded with lower accuracy than Non-R items (e.g., 'soak'). This outcome can be interpreted to mean that there is an underlying post-vocalic 'r' in Australian speakers' mental lexicon and thus such a mismatch between orthography and phonological representation induced them to suffer difficulty mapping the printed words (e.g., 'cawn') onto the base word (e.g., 'corn'). This possibility leads to speculation that Australian speakers are latently rhotic even though a post-vocalic is not realized on the surface.

However, in the present study, we obtained an interesting and different result from that found for native speakers of English. R-items were responded to with higher accuracy and greater rapidity than Non-R items (Silent condition, 82% vs. 72%; Aloud condition, 81% vs. 76%). This finding clearly demonstrates that low- or intermediate-level Korean L2 speakers had little trouble mapping the printed words (e.g., 'parm', 'bock') onto the base words (e.g., 'palm', 'bark') and thus furnishes support for the suggestion that there is no post-vocal 'r' in word representations. That is, Korean L2 speakers are truly non-rhotic. In this sense, they differ from Australian English speakers. However, since highly proficient Korean L2 speakers did not participate in the current study, it is not possible to conclude that there is no post-vocalic 'r' in the lexicon of all the Korean learners. Highly proficient learners are commonly known to pronounce a post-vocalic 'r' like native English speakers. For this reason, more comprehensive study is needed to see how highly proficient or native-like L2 speakers process the printed words with 'r'-colored vowels.

Here a question naturally arises as to why Korean L2 speakers who participated in the current study are non-rhotic in light of absence of /r/ in the mental lexicon even though a post-vocalic 'r' is represented in the orthography. One possible explanation is that they have difficulty pronouncing a post-vocalic 'r' presumably because of L1 Korean transfer of syllable structures and/or they may not have been exposed to rhotic-r exemplars. It might have hampered storage of a post-vocalic 'r' in word representations. However, it is still not clear which aspect takes greater responsibility between lack of input on the perception side and lack of rhotic pronunciation.

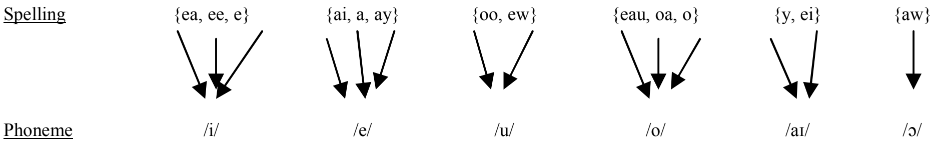
2. Does the Transparency between Orthography and Phonology in English Vary for L2 Speakers?

As explicated earlier, alphabetic orthographies can be classified into two types according to the transparency of correspondences between orthography and phonemes: a shallow orthography and a deep orthography (Frost, 1989; Katz & Feldman, 1981). For instance, in Korean, German, or Serbo-Croatian, one grapheme (or spelling) commonly represents one phonological form. Thus the correspondences between the two are relatively transparent. In contrast, English is characterized as having many-to-many correspondences between orthography and phonological form. Thus it is referred to as an opaque correspondence and can be classified as a deep orthography.

Since Korean speakers are accustomed to a shallow orthography, they are expected to have trouble mastering a deep orthography like English. The current study examined whether they differently process variation of transparency between spelling and phonology within orthography. The results showed that accuracy in the pseudohomophone task varied depending on each type of grapheme-phoneme correspondence. Specifically, accuracy was higher for visual stimuli with consonant graphemes than for those with vowel graphemes. This stems from the different levels of transparency between spelling and phonemes. That is, as clearly illustrated in Figure 3 and 4, correspondences between vowel graphemes and phonemes are characterized as more opaque than those between consonant graphemes and phonemes. It might be the case that subject had trouble mapping a wider variety of vowel spellings onto the appropriate vowel phonemes.

FIGURE 3

A Schema for Correspondences between Vowel Grapheme and Phoneme



Looking into accuracy from the perspective of the association of vowel graphemes and phonemes, Korean L2 participants retrieved the base words from the printed words with spellings "ai, a, ay", "oo, ew", and "y, ei" more accurately than from the other spellings in both Silent condition and Aloud condition. Since other correspondences concerning the phonemes /i, o/, the transparency between spelling and phoneme alone does not suffice to explain comparatively high accuracy for such correspondences. Thus in order to see if the frequency of the base words related to the visual stimuli affects mapping the visual stimuli onto the base words, we examined the token frequency of the base words related to the printed stimuli.[5] Frequency was abstracted from Kučera and

5 As anonymous reviewers point out, the layout of materials have some limitations with regard to frequency of base words. First, since the current study was not originally designed to consider the frequency factor but focused on the relation between spellings and underlying phonemes, it was hard to perfectly match the frequency of the base

Francis (1967) based on around 1 million words in the corpus. It was found that the average token frequencies of the base words with the underlying phonemes such as /e, u, aɪ/ were relatively higher than those with the other vowel phonemes (i.e., 140 for /e/ 'lake, gain, name, great'; 86 for /u/, 'fruit, shoe, grew, true'; 128 for /aɪ/, 'line, died, kite'). Compared to such high-frequency base words, those of the other base words were rather low (i.e., 10 for /i/, 'sneeze, niece, beam'; 27 for /o/, 'though, blow, soak, phone').

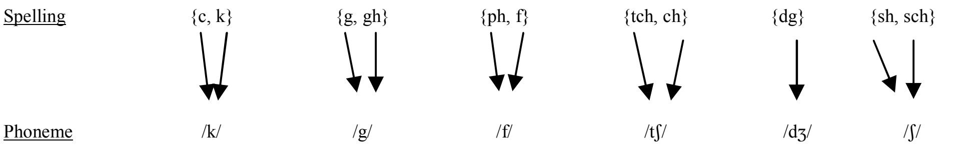
Put together, these results in this study offer an interesting implication that both the transparency between spellings and phonemes and the token frequency of the base words exert an influence on mapping the visual stimuli onto the words in the mental lexicon. It seems that Korean speakers whose L1 Korean is a shallow (or transparent) orthography exploit the frequency of the base words to process a deep (or opaque) L2 English orthography. This position is against Frost and Katz (1989) that word frequency is not the factor, but only orthographic depth influences phonology.

When it comes to the correspondences between consonant graphemes and phonemes, it was found that accuracy was comparatively higher for the visual stimuli containing consonant graphemes such as 'c, k' 'ph, f', and 'tch, ch' (respectively, 83%, 83%, and 78%) than for other stimuli. This finding indicates that it might have been more efficient to map these spellings onto the underlying phonemes such as /k, f, tʃ/ than the other phonemes such as /g, dʒ, ʃ/. Looking into each correspondence in Figure 4, it seems that the degree of the transparency between spelling and phonemes cannot handle the varying levels of accuracy for accessing the base words in the lexicon. Here again we examined the frequency of the base words related to the visual stimuli containing consonant graphemes. The results showed that the higher the average token frequencies of the base words with the underlying phonemes such as /k, f, tʃ/ were, the more accurate their lexical retrieval was (e.g., 241 for /k/, 'thin<u>k</u>, <u>c</u>ar, <u>ch</u>orus'; 96 for /tʃ/, '<u>ch</u>ip, na<u>t</u>ure, wa<u>tch</u>'; 58 for /f/, '<u>ph</u>one, rou<u>gh</u>, o<u>ff</u>er'). In a nutshell, these results lead to the suggestion that, the transparency between grapheme and phoneme being equal, the frequency of the base words facilitates the mapping of the orthography onto its correspondent phoneme.

words. Second, the lexical neighborhood density for the base words might be another potential factor to affect processing the pseudohomophones. A brief look into the data shows that higher frequency base words seem to have more lexical neighbors. Third, frequency of the correspondence of a specific grapheme and a phoneme might be a possible knowledge to affect the processing. A thorough examination of these factors will be left open to future research.

FIGURE 4

A Schema for Correspondences between Consonant Grapheme and Phoneme



Furthermore, these results seem to support Seidenberg's (1985) claim that phonological representations of the frequent words are derived post-lexically after lexical access is executed.

In sum, it was found that that the accuracy and speed of accessing the base words (i.e., mapping the orthography onto the underlying phonological representations) varies according to each type of correspondence between vowel or consonant grapheme and phonemes. This is remarkable in providing additional support for the claim that the visual stimuli are directly recoded into phonological representations on the basis of orthography. Additional evidence comes from the account based on the frequency of the base words. That is, the phonological representations of the words seem to be retrieved after lexical access has occurred because the accuracy for association of grapheme with phonemes is affected by the frequency.

3. Pedagogical Implications for L2 English Teaching

Our results provide pedagogical implications concerning teaching Korean learners about the relations between spellings and their pronunciations. First, it is suggested that they should be explicitly taught about the pronunciation of a post-vocalic /r/ or be exposed to authentic spoken materials containing it. If they do not use 'r-less vowels for a long time, their pronunciations are likely to be fossilized on the production side. Second, it indicates that they are expected to suffer difficulty perceiving such words when communicating with native American speakers of English. Of course, they might have little difficulty communicating with other non-rhotic speakers or L2 speakers, but rhotic speakers might have difficulty processing non-rhotic speaker's utterances. Finally, it is proposed that Korean students get formal instructions for the correspondences between spellings and phonemes, especially those which turned out to be difficult for processing the pseudohomophone tasks.

Ⅴ. CONCLUSION

This study showed that there is no post-vocalic ‘r’ in the phonological representations of Korean L2 English lexicon. Furthermore, it was found that the efficiency of L2 word retrieval is to some extent determined by their knowledge about grapheme-to-phoneme conversion rules (or the association strength between spelling and phoneme) in English. Another interesting finding is that another factor which shapes the connection between orthography and underlying phonological representations is the frequency of the words in the lexicon. This implicates that the frequency information may be encoded in the lexicon, and phonological representations are available after the relevant words are accessed.

As mentioned earlier, more work is needed to see if the status of a post-vocalic ‘r’ holds true for native-like or highly proficient English learners’ phonological representations. Another interesting issue to be addressed is whether or how Korean L2 speakers exploit a shallow Korean orthography and at the same time English L2 deep orthography. Assuming that orthographic depth has a psychological reality, would it be possible to have an L1 shallow orthography and develop an L2 deep orthography?

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APPENDIX

1. R items (base words)

forl (fall)	cawn (corn)	wod (word)	taw (tore)
saw (sore)	paw (pore)	fawn (form)	alm (arm)
parm (palm)	carm (calm)	baht (bart)	hot (heart)
dot (dart)	tot (tart)	cot (cart)	shop (sharp)
cob (carb)	bob (barb)	mock (mark)	dock (dark)
bock (bark)	bun (burn)	tough (turf)	fun (fern)

2. Non-R items (base words)

sneaz (sneez)	neece (niece)	beme (beam)	laik (lake)
gane (gain)	naim (name)	grayt (great)	ges (guess)
froot (fruit)	she (shoe)	groo (grew)	troo (true)
theau (though)	bloa (blow)	soke (soak)	foan (phone)
tawk (talk)	brawd (broad)	dawg (dog)	dyd (died)
keight (kite)			
thinc (think)	kar (car)	korus (chorus)	gost (ghost)
egh (egg)	bagh (bag)	fone (phone)	rouph (rough)
opher (offer)	tchip (chip)	nachure (nature)	wach (watch)
madgic (magic)	siedge (siege)	qween (queen)	qwick (quick)
qwit (quit)	schure (sure)	shuper (super)	tenshion (tension)

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