

# Korean Speakers' Sensitivity to the Stochastic Patterns Governing Vowel-to-grapheme Mappings in English\*

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Lee, Yongeun. 2009. Korean Speakers' Sensitivity to the Stochastic Patterns Governing Vowel-to-grapheme Mappings in English. *The Linguistic Association of Korea Journal*. 17(3). 39-55. Previous studies report that native speakers of English make use of stochastic patterns governing vowel-to-grapheme mappings in English when they spell vowels appearing in unfamiliar English words. The current study explores whether the same type of factor plays a role for Korean EFL learners in their converting vowels appearing in (auditorily presented) unfamiliar English words to vowel graphemes. The results from the current study indicate that Korean speakers' spellings of word-medial English vowels are affected by two types of statistics: (i) how often a vowel is spelled with a particular grapheme before a specific coda consonant and (ii) how often a vowel is spelled with a particular grapheme in the English lexicon in general. We suggest that the current results are in favor of the view that an important process of learning an L2 involves acquiring stochastic phonology-to-grapheme mapping patterns that L2 learners encounter when they are exposed to a target language.

**Key Words:** statistical learning, sound-to-grapheme mappings, L2 lexicon

## 1. Introduction

Previous research indicates that while translating sounds into graphemes,

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English speakers make use of probabilistic patterns governing sound-grapheme mappings in English. More specifically, previous studies have reported that English speakers make use of, for example, surrounding context when they convert sounds to letters. With regard to this, firstly, there is evidence that suggests that sound-spelling correspondences in English is more systematic than is commonly thought. Kessler and Treiman (2001), for example, demonstrated that although English vowel /ɔ/ is spelled in a number of different ways in English words (e.g., *a* in *salt*, *al* in *talk*, *o* in *fork*, and *ough* in *thought*) with the most often spelling of the vowel being *au* as in *flaunt*, the possible spelling window of this vowel is significantly reduced such that /ɔ/ is always spelled with *aw* when the sound appears before /n/ or /k/ within an English mono-syllable word, as in *lawn*. They report that there is no exception to this pattern in English. This suggests that the context in which a sound appears in part can determine how the sound is spelled in English.

Secondly, what is of a great relevance to the current paper is that this kind of stochastic patterns governing sound-letter mappings does not merely exist as a statistical artifact found across the words in the English lexicon. Rather, it is psychologically real in that English speakers are implicitly aware of them and do take advantage of the stochastic patterns when they are asked to map sounds to letters in experimental settings (for evidence from adults, see Kessler & Treiman, 2004; Treiman, Kessler, & Bick, 2002; Perry, Ziegler, & Coltheart, 2002 and for evidence from children, see Juul, 2005; Treiman & Kessler, 2005; Varnhagen, Boechler, & Steffler, 1999; Marsh, Friedman, Welch, & Desberg, 1980).

Given the existence of stochastic patterns governing sound-to-letter mappings in English and English speakers' sensitivity to them, the primary question the current paper asks is whether or not the same type of process may also play a role for Korean EFL learners in their relating English sounds to letters. That is, I explore in this study the question of whether or not adult Korean EFL learners take advantage of the stochastic patterns regarding how sounds are mapped onto spellings in English words (not how spellings are mapped onto sounds). An affirmative answer to this question should contribute to the research field of acquisition of L2 sound-letter mappings and more generally of lexical access in L2 languages.

The current study begins with the hypothesis that in spelling English sounds,

Korean learners of English may also make use of the probabilistic patterns governing sound-to-letter mappings found with the words in their L2 lexicon. If Korean EFL learners indeed make use of such mappings and more specifically that if they are sensitive to the stochastic patterns regarding how sounds are mapped onto spellings in English words, then they should show (among others) effects of context in spelling, as native speakers of English do. For example, if Korean EFL learners are asked to spell an (auditorily presented) English nonword whose pronunciation is /sɔn/, they would spell the word with *sawn* significantly more often than with other possibilities, since (as mentioned above), according to the previous reports, in English /ɔ/ is always spelled with *aw* before syllable-final /n/ within a word. This hypothesis was tested in the following experiment.

## 2. Methods

In order to test the hypothesis, the current study asked Korean EFL learners to spell medial vowels appearing in auditorily presented English CVC monosyllabic nonsense words, and examined whether the spellings of the vowels were influenced by the identity of the coda consonant. This specific task is borrowed from the experimental technique previously used in studies such as Hayes et al. (2006) and Treiman et al. (2002). As mentioned above, the principal idea behind this task is that if Korean EFL learners are sensitive to the stochastic patterns governing sound-to-spelling relationships in English, the same vowel will be spelled differently when it occurs before a certain coda consonant than when it occurs before other coda consonants. The task at hand is then to find two contrasting environments such that a particular spelling of a vowel occurs significantly more often in one case than the other. Below I first explain how this set of environments was constructed.

### 2.1 Stimuli construction

In order to construct the target stimuli that reflect this experimental design, I first examined the spelling of each vowel phoneme in a set of English monosyllabic words that I assumed most Korean college students would be

familiar with in print. This consideration made the words appearing in middle school English textbooks an ideal set of words since they are all relatively high-frequency words and are thus likely to be highly familiar as well to Korean learners of English. The constructed list contained a total of 1245 mono-syllabic mono-morphemic words.

Following the procedure laid out in previous studies such as Hayes et al. (2006), Kessler and Treiman (2001), and Treiman et al. (2002), I calculated what is termed in the literature as conditional consistencies of sound-to-spelling mapping. This statistic basically gives us the size of the context effect in the spelling of English sounds (in the current case, the English vowel sounds). For example, to calculate the conditional spelling consistency of the vowel sound /i/ given a particular coda consonant within the same syllable (i.e., how does the spelling of vowel /i/ vary depending on a certain following consonant within the same syllable), I computed the spelling consistency of vowel /i/ before every coda consonant found in the current English CVC word list reported above. That is, I computed how often /i/ is spelled with *ea* before a coda consonant in the 1245 English words. I also computed how often /i/ is spelled with spellings other than *ea* before a coda consonant. I repeated this procedure for each of the vowel sounds in the word list. Type frequencies were used for all computations reported here. This means that no matter how often a given word appears in the middle-school English textbooks, it was counted only once for the purpose of calculations here.

The finding from the current calculations is reported in Table 1. It lists some details of the effect of the coda consonants on the spellings of vowels. Firstly, the second column in the table shows the default or the most common spelling for a given vowel found in the current word list. Thus, for example, the most common spelling of vowel /ɛ/ is the grapheme *e* in the current word list (as in *leg*). Secondly, the fourth column in the table shows the variants of the spellings that are statistically significantly affected by the coda sound (all at the level of  $p < 0.05$ ). Thus, for example, although the most frequent spelling of vowel sound /ɛ/ is *e* in the current word list, the same sound is most frequently spelled instead with the letter sequence *ea* when the sound occurs specifically before the coda consonant /d/, as in *head*. That is, the likelihood that we find the letter sequence *ea* before the coda consonant /d/ as a spelling of the vowel /i/ (when

computed across the 1245 words) is more than 95%.

Likewise, the most common spelling of the vowel /i/ is *ea*. However, crucially the same sound is rather most likely spelled with *ee* when it is followed by /d/ or /p/ within the same syllable, as in *deed* and *deep*, respectively. Thus, the likelihood that the vowel sound /i/ is spelled with spellings other than *ee* is greatly reduced in a situation where the sound is immediately followed by the sound /d/ or /p/ within the same syllable.

Table 1. Effects of coda consonants on the spelling of English vowels

Vowel	Most common spelling	Example	Spelling significantly affected by coda*	Triggering coda consonant	Example
/ɛ/	e	leg	ea	/d/	head
			ee	/d/	deed
/i/	ea	reach	ee	/p/	deep
/o/	o_e	cone	o	/l/	toll
			u	/l/	bull
/ʊ/	oo	mood	u	/s/	puss
			u	/ʃ/	push
			u	/tʃ/	butch
			ow	/l/	howl
/aʊ/	ou	couch	ow	/n/	town
			igh	/t/	fight
/aɪ/	i_e	wide	al	/m/	calm
			ou	/f/	rough
/ʌ/	u	rug	o_e	/v/	love
			o	/ɔ/	song
/ɔ/	au	cause	al	/k/	chalk
			a	/l/	tall
			aw	/n/	dawn
			ai	/l/	fail
/eɪ/	a_e	page	ai	/n/	gain
			o	/m/	tomb
/u/	oo	tool	ou	/p/	soup
			u	/t/	suit
			o_e	/v/	move

\*all at the significance level of  $p < .05$

Based on these consistency calculations, the target stimuli were prepared. Again, the principal idea for constructing the target stimuli was to prepare pairs of monosyllabic CVC English nonwords that differ from each other only in coda and to see whether the behavioral patterns of Korean EFL learners' spelling English vowels are affected by the coda sound. Let us take the pair of nonwords /gɛd/ and /gɛtʃ/ as an example. Note that these are a pair of English nonwords that differ only in coda. As shown in Table 1 above, according to the vowel spelling consistency measures reported above, an important statistical pattern governing the spelling of the vowel /ɛ/ is such that it is significantly more likely to be spelled with *ea* before the coda consonant /d/ than when the sound occurs before other consonants such as /tʃ/. In fact, in the word list constructed in this study, /ɛ/ is never spelled with *ea* when the sound is followed by /tʃ/. Likewise /ɛ/ is never spelled with *ea* when the sound is followed by /b/, /dʒ/, /g/, /k/, and /p/. Thus the expectation is that if Korean EFL learners are indeed sensitive to the statistical pattern governing sound-to-letter relation in English lexicon (that is, if they have knowledge about the effect of coda on spellings of vowel consonants within mono-syllabic English words), then they should spell the vowel /ɛ/ appearing in /gɛd/ significantly more often with *ea* than they spell the same vowel in /gɛtʃ/ with *ea*.

By the same logic, the calculations performed in the current study reveal that the *ee* spelling of the vowel /i/ is found significantly more often when the vowel is followed by /d/ (e.g., *seed*) or by /p/ (e.g., *deep*) than when the same vowel is followed by other consonants such as /m/ (e.g., *team*). In the case of the vowel /o/, it is most often spelled with *o* when it is followed by /l/ (e.g., *toll*), although the vowel's most common spelling in the word list overall is the discontinuous letter group *o\_e* (e.g., *bone*). In the case of /ʊ/, it is spelled with *u* before /l/, /s/, /ʃ/, or /tʃ/. When /ʊ/ is spelled before consonants other than these four consonants, the vowel is most likely spelled with *oo* (e.g., *mood*). In the case of /aʊ/, this vowel is most likely spelled with *ow* before final /l/ (e.g., *howl*) or /n/ (e.g., *town*), although it is usually spelled with *ou* in other context (e.g., *house*). Finally, in the case of /aɪ/, it is most likely spelled with *igh* before /t/, while the most common spelling for the sound is the discontinuous letter sequence *i\_e*. Examples of words that illustrate this consideration are all given in Table 1.

## 2.2 Experiment design

The current study focused on examining the patterns from Korean EFL learners' spelling these aforementioned six vowels (i.e., /ɛ/, /i/, /o/, /ʊ/, /aʊ/, and /aɪ/), primarily because the effect of coda consonants on the selection of spellings of these six vowels have been independently verified in previous lexicon studies larger than the current one. Specifically, in Kessler & Treiman (2001)'s study, the likelihood that /ɛ/ is spelled with *ea* before a coda consonant such as /tʃ/, /b/, /dʒ/, /g/, /k/, or /p/ was zero, as was the case in the current study. Thus, there is a clear difference in terms of how /ɛ/ is spelled before the coda consonant /d/ and how /ɛ/ is spelled before coda consonants such as /tʃ/. The same was true of the rest five vowels.

Following the terms used in Treiman et al. (2002), I am going to refer to the particular spelling that is conditioned by a specific coda consonant as "critical spelling". Thus, the critical spelling of /ɛ/ before /d/ (within monosyllabic English words) is *ea*. The critical spelling for /i/, /o/, /ʊ/, /aʊ/, and /aɪ/ is then *ee*, *o*, *u*, *ow* and *igh*, respectively. Thus, the critical spelling for a given vowel is the spelling that is *specific* to the vowel in a *particular context* (that is the particular spelling before a particular coda consonant). The current experiment is designed to determine whether Korean EFL learners are implicitly aware of this kind of critical spellings for the six English vowels in question.

Table 2 lists the target stimuli used in the current study that take this into consideration. In the third and sixth column of the table, note that "control spelling" refers to the context where the critical spelling of a given vowel never occurs in the current as well as in Kessler & Treiman (2001)'s study. To take the nonword pair of nonwords /kled/ and /kleb/ for an example, in the lexicon analyses of both Kessler & Treiman (2001)'s and the current studies, /ɛ/ is never spelled with *ea* before /b/. This control spelling was designed to contrast the critical spelling of /ɛ/ before /d/ and the spelling of the same sound before /b/. This strategy will allow us to test the hypothesis that Korean EFL learners (if they behave like native speakers of English) will provide the critical spelling of /ɛ/, i.e., *ea*, significantly more often before /d/ than they will before the control sound (i.e., before /b/). The target stimuli used in the current study are borrowed in part from the stimuli used in Appendix of Treiman et al. (2002).

Table 2. Target stimuli (adopted in part from Treiman et al., 2002: p. 466)

target vowel	critical spelling	control spelling	target vowel	critical spelling	control spelling
/ɛ/	/klɛd/	/klɛb/	/ʊ/	/smɔl/	/smɔf/
	/smɛd/	/smɛk/		/jɔʃ/	/jɔʃ/
	/strɛd/	/strɛp/		/slɔʃ/	/slɔk/
/i/	/zip/	/zist/	/aʊ/	/mɔl/	/mɔʃ/
	/prid/	/prig/		/vaʊn/	/vaʊs/
	/snip/	/snim/		/braʊl/	/braʊʃ/
/oʊ/	/grɔl/	/grɔk/	/aɪ/	/glart/	/glarb/
	/jɔl/	/jɔp/		/jart/	/jais/
	/skoʊl/	/skoʊp/		/gart/	/garif/

In addition to the 18 critical and 18 control stimuli, there were 16 filler items (some of these items were also borrowed from Treiman et al, 2002). They were /his/, /frɪp/, /deɪ/, /fɛk/, /hɔf/, /gɔb/, /flʌ/, /ʃɔn/, /splʌʊ/, /jit/, /ʃig/, /zeɪ/, /skɛt/, /væsp/, /græk/, and /spʌŋ/. These filler items contained some vowels and consonants that did not appear in the critical and control items. The filler items were intended to minimize repetitive appearance of target stimuli in the experiment. In presenting the stimuli to the participants, I used two different sequences; thus, half of the participants were assigned to a sequence of presentation and another half to a different sequence of presentation. In a given list, the critical, control, and filler items randomly appeared with the constraint that no more than two consecutive items involved the same type of stimuli. A phonetically trained native speaker of English read the stimuli in a quiet room, which were tape-recorded using a portable digital recorder and auditorily presented later to the participants.

### 2.3 Participants

13 (5 female, 8 male) native Korean learners of participated in the experiment. They were all undergraduate students. They were paid for their participation. None reported any history of speech or hearing impairment and none has resided in countries that use English as their first language longer than a year.



It is possible that among other factors the level of proficiency in L2 may influence the extent to which Korean learners of English show sensitivity to sound-to-spelling correspondences in English. Thus, the current study made efforts to make the pool of the Korean-speaking participants to be as homogeneous as possible in terms of their English proficiency by performing the following English proficiency test to the participants.

The test administered to indirectly measure English proficiency of the Korean participants was a speaking test in which participants spoke on their own pace for about two minutes in English in response to a simple question from the current author (i.e., tell me about what you did last weekend). The responses were tape-recorded and portions of the response of each participant were subsequently presented to a native speaker of English to assess roughly the degree of fluency in the participant's speech (as an indirect measure of the participants' English proficiency). The judge basically listened to a short excerpt from each participant's recording (mean 60 seconds) and rated each sample using a 9-point scale for degree of fluency (1 = not fluent at all, 9 = very fluent). The judge gave his ratings on a score sheet. The obtained scores ranged between 4 and 7, with a mean fluency rating of 5.1. Most of the subjects obtained 5 or 6, which I take to suggest that the pool of the subjects was quite homogeneous in terms of English proficiency.

In addition to this, participants were asked to self estimate their proficiency of English in writing, reading, listening, and speaking on a 10-point scale (1 = extremely poor, 10 = extremely fluent). Their estimation of their overall proficiency was at a mean of 5.3 (ranging from 3.5 to 7.0).

## 2.4 Procedure

The participants were tested in groups of two or three in one session in a quiet room. Each group was randomly assigned to one of the two presentation orders. The participants were asked to first hear the (pre-recorded) nonword stimuli and then to write them in standard English orthography on an answer sheet. Specifically, they were told that a company is developing English brand names of commercial products to be used in the future and that the company is in the process of collecting data on how the English names should be spelled.

This instruction was adopted because of two reasons. First, explaining the notion of English nonwords *per se* to the learners of English was difficult. Second, past studies have indicated that there is tendency that when asked to process nonwords, participants do so with atypical orthographic patterns assuming that very unfamiliar words should have such atypical orthography. The instruction was intended to avoid this tendency. The participants' spellings were collected and analyzed.

### 3. Results

The spellings of the test nonword stimuli were transcribed (by the current author) as having the critical spelling of the vowel or some other spellings. Thus, in the case of the target nonword /kled/, for example, I scored how often the vowel sound of the nonword was spelled as *ea* (i.e., the critical spelling of the vowel) or some other spellings.

In analyzing the spellings of the stimuli, I made it an operational rule that as long as the participants got the *final* consonant of the stimuli correctly, I included the item into the analysis. For example, one of the participants in the current study actually spelled the target stimulus /strɛd/ as *scread*. Note here that a proper way of spelling the initial consonant cluster of this word should be *str-* not *scr-*. Despite this, I considered this response as one instance that has the vowel spelling of *ea* before /d/, since the participant got the final consonant of the word correctly. By the same logic, if a participant produced spellings such as *streq* when the target stimulus was /strɛd/, I considered this to be an indicative of the fact that the participant did not perceive the stimulus correctly and thus exclude the spelling *streq* from the further analysis. This procedure was taken since the critical condition for constructing the current stimuli was the effect of the coda consonants on the spelling of the vowels. Any incomplete responses or any sequences of spellings that violate the constraints on the standard English grapheme sequences (such as *sangt* as a mono-syllable word) were not included in the analysis.

Table 3 shows the proportions of the spellings that used the critical vowel for the experimental and the control nonwords. Recall here the current

hypothesis that if Korean EFL learners are sensitive to the stochastic patterns governing sound-to-spelling correspondences in English, then they should use the critical spellings significantly more often for the experimental items than for the control items. To take the pair of /gɛd/ and /gɛtʃ/ for an example, the hypothesis is that we will find *ea* spelling more often for /gɛd/ than for /gɛtʃ/. The result in Table 3 indicates that the mean proportion of *ea* spelling (i.e., critical spelling) was indeed greater for the experimental nonwords (18%) than for the control nonwords (5%). Note that the sum of these two proportions is 23% (= 18% + 5%), meaning that the rest 77% were “incorrect” responses that were excluded from the current analysis (i.e., as mentioned above, incorrect responses included such cases as subjects did not get the final consonants correctly or the responses were incomplete or the produced sequences of spellings violated the restrictions on the standard English grapheme sequences)

Table 3. Results of the Experiment

	/ɛ/	/i/	/oʊ/	/ʊ/	/aʊ/	/aɪ/
Mean (SD) % of critical spellings, experimental nonwords	.18 (.31)	.28 (.25)	.36 (.34)	.27 (.27)	.37 (.28)	.23 (.24)
Mean (SD) % of critical spellings, control nonwords	.05 (.08)	.44 (.10)	.57 (.23)	.00 (.00)	.07 (.12)	.00 (.00)
<i>t</i> -test by subjects	<i>p</i> =.01	<i>p</i> =.06	<i>p</i> =.03	<i>p</i> =.08	<i>p</i> =.23	<i>p</i> =.02
<i>t</i> -test by items	<i>p</i> =.02	<i>p</i> =.19	<i>p</i> =.21	<i>p</i> =.01	<i>p</i> =.01	<i>p</i> =.01

In order to determine whether the difference in mean proportion of the spellings between the two types of stimuli is statistically significant, I carried out for each vowel *t*-tests by subjects and by items. The third and fourth row of Table 3 contain the results. First, there were significantly more critical spellings

for the experimental items than the control items for the two vowels of /ɛ/ and /aɪ/ (significant both by subjects and by items). Similarly, there were more critical spellings for the experimental items than for the control items for the two vowels of /ʊ/ and /aʊ/ (in this case significant by items only). Thus in the case of /ɛ/, /aɪ/, /ʊ/ and /aʊ/ the general pattern is that when Korean speakers spell English vowels, the local context in which the vowels occur (i.e., in this case the nature of the following consonants) influences the spelling of vowels.

However, the results in Table 3 also indicate that the current participants did not always use more critical spellings for the experimental items than for the control items. The case of vowel /i/ is one such example which nearly missed the significance level (at least in terms of by subjects analysis) but in the opposite direction. That is, the current participants overall used spellings other than the critical spelling numerically more often when they wrote the experimental items that contain the vowel /i/. Specifically, when the participants heard the target stimuli containing /i/ such as /snip/, they used spellings such as *sneap* much more often than the expected spelling of *sneep*. This is interesting considering the fact that in the 1245 English words surveyed in the current study, the likelihood that the vowel /i/ is spelled with *ea* before the coda consonant /p/ was less than 5%.

The difference in terms of the *p*-values by subjects analysis (near significance) and by items analysis (non-significant) in the case of vowel /i/ spelling suggest that there were some differences in terms of spellings among the individual target items containing the vowel /i/. A post hoc check revealed that among the three target items containing /i/ (i.e., /zip/, /prid/, and /snip/) whose expected critical spelling of the vowel is *ee*, the vowel sound /i/ in the stimulus /zip/ was spelled with the vowel letter *i* (like *zip*) 100% of the time, while the same vowel in the stimulus /prid/ and /snip/ was spelled with the vowel letter *i* 50% and 0% of the time, respectively. This looks like the effect of the actual word *zip* on the current task. Finally, in the case of spelling /oʊ/, the current participants also used spellings other than the critical spelling more often when they wrote the experimental items that contain the vowel /oʊ/. Specifically, when the participants heard the target stimuli containing /oʊ/ such as /groʊl/, they used spellings such as *groul* much more often than the expected

spelling of *growl*.

#### 4. Discussion and conclusion

The current study asked whether Korean EFL learners' spellings of English medial vowels in English spoken nonwords vary as a function of the context. That is, we tested whether the same vowel could be spelled differently when it occurs in a context than when it occurs in other context. The context is defined here as the appearance of a vowel sound before a specific coda consonant within a syllable. The current results concerning this hypothesis are mixed.

First, the results indicate that Korean learners of English do show some sensitivity to the identity of coda consonants when they spell certain English vowels. In the case of the pair of nonwords /gɛd/ vs. /gɛtʃ/ for an example, the current participants used the *ea* spelling (i.e., critical spelling) significantly more often for the experimental nonwords than for the control nonwords. This finding is consistent with previous findings from comparable experiments with English speakers. Treiman and Zukowski (1988), for example, report that English adult speakers are sensitive to statistical regularities found with vowel-to-coda sequences only in spelling production but not to those found with the English lexicon as a whole. Treiman et al. (2002) also reported similar effects.

One explanation for the effect of this kind of context on vowel spelling comes from the inherent complexity behind sound-to-spelling mappings in English. When learners of English (both native- and EFL-learners alike) deal with the complex variability of English vowel spellings, they have to go beyond simple phoneme-to-grapheme mappings since this, as is well known, quite often yields incorrect spellings. One way to avoid this spelling mistakes is then to find a sound-spelling correspondence domain larger than the individual vowels and consonants. In English the domain is highly likely to be the one that includes vowels and coda consonants, which in phonology is called rimes. Then the idea is that rimes are not just a unit for phonological processing but also a domain where statistically significant sound-spelling relationships can be defined and learned in English. In other words, the rime is a unit that is learned when learners of English try to deal with complex sound-grapheme mappings in English.

The English lexicon study by Kessler and Treiman (2001) that examined virtually all of the monosyllabic, monomorphemic words of English is in fact in favor of this idea (i.e., rimes as a unit where significant sound-letter correspondences can be defined). The result showed that although sound-to-spelling relationships for vowels are quite variable, the coda consonant has a statistically significant influence on the spelling of the vowel. This effect was much more reliable than the comparable effect that onset consonants had on the spelling of the vowel in English. What this means to Korean learners of English as a foreign language is that they may also pick up this unique statistical pattern in English during the process of learning (as native speakers of English may also do) and they might take advantage of it when they are asked to spell English sounds. In this way, Korean EFL learners can avoid learning to spell English words by rote.

The discussion thus far suggests that Korean EFL spellers may not simply store a list of the possible spellings of each vowel. They are able to map a vowel sound to a particular vowel spelling in the context of rimes. The current results, however, are also partly consistent with view that Korean learners of English simply use the English vowel grapheme that most typically spells the vowel in English in general when they map vowels to graphemes. That is, contrary to what we just said above, part of the current results suggest that Korean EFL learners store a list of the possible spellings of each vowel and their use of a specific vowel spelling is determined by simply how frequently a vowel sound is spelled with a specific vowel grapheme or grapheme sequence in the English language as a whole. Under this view, the choice of a specific vowel spelling for a given vowel sound is not determined by the statistic that is computed in the context of a vowel plus a coda consonant but by the statistic that is computed across the English words in general.

To take the case of spelling the vowel of /i/, for example, the current participants produced *ea* spellings much more often than *ee* spellings not only for words that contain coda /d/ but also for other words. This is somewhat surprising in the sense that pooled across the English monosyllabic words examined in the current study, the likelihood that /i/ is spelled with *ea* before /d/ is less than 5%. But if we assume that Korean speakers are sensitive to the vowel spelling that is most common in the English lexicon as a whole, then the

finding is not so surprising. Rather, this can be understood easily by the fact that *ea* spellings are the most frequent grapheme sequences for the words that contain the vowel /i/ in English in general (see Table 1). That is, the explanation is that our participants might have been aware of this fact and that they used this sequence of graphemes in writing /i/ even though the most frequent spellings before /d/ in CVC English words is *ee*.

With regard to this, Barry and Seymour (1988) and Perry et al. (2002) also reported similar results with English speakers, where they showed that English speakers' grapheme option is sensitive not only to the vowel-coda context but also to the lexicon as a whole. More specifically, Barry and Seymour (1988) examined nonwords such as /teɪn/. The most common spelling of the vowel in the rime consisting of /eɪn/ is *ai*, while the most common spelling of the vowel /eɪ/ in the English language as a whole is *a\_e*. The English-speaking participants in their study tended to provide the vowel spelling that was the most common in the English lexicon as a whole rather than the vowel spelling that was the most common in the particular rime. Barry & Seymour (1988) and Perry et al. (2002) concluded that with regard to spelling production their participants used individual phoneme-grapheme sized relationships instead of use of rimes. The results from both English speakers' and Korean EFL learners' production of English vowel spellings then indicate that although rimes are a useful unit of spelling and play a role in spelling, they are not the only unit of spelling. Thus, as far as the matter of spelling English vowels is concerned, both experienced (native) spellers of English and spellers of English as a foreign language are alike in that they deal with the vowel-spelling complexity by using both the single phoneme and the context that extends beyond the single phoneme.

Finally there are two considerations that remain an open question for a future follow-up study. The first is the effect of existing words on spelling of vowel sounds. We saw above that the current participants produced more *i* spelling for /zip/ than the expected *ea* or *ee* spelling. One obvious explanation for this is that it is the actual word *zip* that influence the choice of the spelling *i* for the /i/ sound here. If this is the case, then the number of orthographic neighbors of a given word (i.e., orthographic neighborhood density) can influence the choice of spellings of English vowels. A future study that controls

for this factor can shed lights on this issue.

The second question is the potential effect of *onset-to-vowel* context on spelling English words by Korean learners of English. That is, whether or not Korean EFL learners are sensitive to the effects of onsets as well as codas on vowel spelling. For example, in spelling the vowel /ε/, our participants typically used the critical spelling *ea* for the target stimulus /strɛd/. However, in spelling the same vowel, our participants quite often used the spelling *a* for the target stimulus /klɛd/. One possible account of this difference might be that although *ea* is the most likely spelling for the vowel /ε/ before /d/, *a* is also the most likely spelling for the vowel /ε/ after the consonant cluster /kl/ in English. The effect of onset-vowel context may have overridden the effect of vowel-coda context when the participants produced the spelling for /klɛd/. A future study could address this issue.

To summarize, the current study showed that Korean EFL learners are sensitive to sound-to-spelling correspondences in English. As such, the current study is in favor of the view that as is the case for acquiring a native language, learning an L2 also reflects acquisition of probability-based phonological and grapheme patterns that learners encounter when they are exposed to a target language.

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