English Teaching, Vol. 73, No. 1, Spring 2018
DOI: 10.15858/engtea.73.1.201803.71

Natural Order of Non-native Phonology in L2 English Produced by L1 Korean and Chinese Adults*

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Kim, Jong-mi, & Go, U-ri. (2018). Natural order of non-native phonology in L2 English produced by L1 Korean and Chinese adults. *English Teaching, 73*(1), 71-94.
This study investigates whether a natural order exists for non-native acquisition in the production of English syllable coda obstruents by Korean and Chinese adult native speakers. We recorded L2 English monosyllabic words produced by 66 Chinese and 51 Korean native speakers. The recorded speech was then evaluated by 11 native-speaker listeners of English to determine the accuracy of coda consonants. The results showed that in both Chinese and Korean languages, the mean proportion of L2 forms was consistently ordered across all groups of different proficiencies: Substitution > Insertion > Deletion. Our results support the Natural Order Hypothesis that non-native phonology has the same general order, no matter what might be the language proficiency of the learners or the learners' native language. However, the results do not support the view that this order is the acquisition sequence or the difficulty order. Other findings include that non-native phonology operates according to recoverability rather than transfer or markedness.

Key words: order of acquisition, non-native phonology, English syllable, recoverability

* This study was supported by a 2016 Research Grant from Kangwon National University (No. 520160104). The paper has greatly benefited from the generous support of the Department of Linguistics at the University of Southern California, where the author was able to run part of the experiment and to use the phonetics laboratory. The author also appreciates the assistance received from Hua Zhang in preparing the audio files of Chinese learner speech and participating in the initial stage of this work. An earlier version of this paper was presented at the Seoul International Conference on Speech Sciences (SICSS), November 2017, Seoul, Korea.
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1. INTRODUCTION

1.1. Natural Order of Acquisition

The “natural order” of language acquisition has become a long-standing discussion with some disagreements (See Hulstijn, Ellis, & Eskildsen, 2015; Ellis, 2015 for reviews). The term “Natural Order” has been used to refer to the order of children’s language acquisition as well as to the order of difficulty for adult performers as a manifestation of the acquired system (Krashen, 1981, p. 54). The Natural Order Hypothesis proposed in early studies was that the grammar and vocabulary of a language are acquired in the same general order, no matter what might be the type of learner or language they are acquiring, or whether the language is the first or second language (Baily, Madden, & Krashen, 1974; de Villars, 1974; Dulay & Burt, 1974; Krashen, 1981, p. 52). Several studies have presented more recent evidence, as outlined in Goldschneider & DeKeyser (2005). Goldschneider and DeKeyser conducted a meta-analysis of 12 studies on English morphemes from 25 years of research who have posited a natural order of acquisition common to all ESL learners.

However, some subsequent studies do not support this view based on their own morpho-syntactic evidence (Luk & Shirai, 2009; Murakami & Alexopoulou, 2016; Seog, 2015; Weitze, McGhee, Graham, Dewey, & Eggett, 2011). For example, Murakami and Alexopoulou examined the L2 acquisition order of six English grammatical morphemes by learners of seven L1 groups across five proficiency levels and they found a more severely affected L1 influence than a universal acquisition order of L2 morphemes. In spite of these criticisms, the natural order hypothesis has been generally accepted and influenced language teaching. That is, a given element of grammar is taught when students are ready to learn (Ellis, 2005, p. 216; Tammenga-Helmantel & Maijala, 2018).

The purpose of our study is to investigate whether non-native acquisition of phonology has a natural order and, if so, what the type of acquisition order is for non-native phonology. To the best of our knowledge, few studies have shown whether an acquisition order exists in non-native phonology, while most studies mentioned above have dealt with morphemic or syntactic aspects. Do non-native speakers follow a “natural order” of phonological development in language learning?

To investigate the existence of a natural order in non-native phonology, we limit our domain of investigation to L2 English coda obstruents learned by L1 Korean and Chinese learners. Specifically, we investigate whether and how native speakers of Chinese or Korean follow a natural and fixed order in the acquisition of English singleton obstruents in syllable coda position.

There are two reasons for us to limit our scope of investigation to singleton coda obstruents in English. First, the three languages our learner subjects deal with contrast in their permissible coda obstruents: Chinese syllables have no obstruent coda, Korean syllables have no voiced obstruent coda, and English syllables have all voiced and voiceless obstruents in codas. Second, the scope is limited to only singleton consonants in order to control the experiment. We exclude consonant clusters because they may involve different adaptation strategies by learners. With this research scope, our overarching research query is whether Chinese and Korean learners follow a natural order of learning English coda consonants that significantly differs from that of their native language.

1.2. Syllable Coda Differences in English, Korean, and Chinese

English consonants in syllable coda are likely to test a natural order of acquisition when learned by native speakers of Chinese and Korean, because the phonotactic constraints of these three languages differ significantly. English allows four consonants in a coda position, as in the word *texts* [ksts], but Chinese and Korean syllables allow only a single consonant with specific features in a coda position. Chinese syllables are mostly open with no coda consonant, but allow only /n/ or /ŋ/ in a coda when closed. Korean syllables allow only one voiceless plain stop or one sonorant consonant, of all seven possible phonemes of this category in the phoneme inventory: /p,t,k,m,n,ŋ,l/. The permissible features of syllable codas in Korean and Chinese significantly differ from English, because English coda consonants may be any of all 21 consonants.[1] In contrast to English, Chinese coda consonants are limited to the singletons /n/ or /ŋ/, excluding all of the remaining 19 consonants in the phoneme inventory (Duanmu, 2007, p.24).

In accordance with differences in Chinese, Korean, and English syllable structures, learners may insert, delete, or substitute a coda consonant when producing the target form. Learners may insert a vowel after a syllable coda consonant to form a CV structure (a single consonant followed by a single vowel). For example, a Chinese learner may insert a vowel [ə] after the coda obstruent /g/ in *dog*, [u] after /f/ in *leaf*, and [i] after / dʒ/ in *ridge*. This role of L1 in L2 forms has been termed "transfer" in second-language phonology (Lado, 1957, p. 2), by which learners have cross-linguistic influence in applying L1 grammar to new L2 forms (Odlin, 1989). The concept of transfer in the L1 role in L2 phonology leads to the second issue we want to investigate on the natural order of non-native phonology. We will investigate whether the native-language phonology transfers to the target-language learning, or there is an interlanguage process such as a natural order of acquisition that may not depend on the native-language transfer.

1.3. Universals of Non-native Phonology: Markedness and Recoverability

The third issue we investigate on the natural order of non-native phonology is whether the order is the same across languages. In other words, we want to determine whether non-

[1] English has 21 consonants other than glides (/h/, /j/ and /w/) in the phoneme inventory, as outlined in Ladefoged and Johnson (2015, p. 38): /p/, /t/, /k/, /b/, /d/, /g/, /m/, /n/, /ŋ/, /f/, /v/, /θ/, /ð/, /s/, /z/, /ʃ/, /ʒ/, /l/, /r/, /ʧ/, and /ʤ/. Of these, all eight pairs of voiced and voiceless obstruents are tested in our speech material: /p/, /t/, /k/, /b/, /d/, /g/, /f/, /v/, /θ/, /ð/, /s/, /z/, /ʃ/, /ʒ/, /ʧ/, and /ʤ/.

native speakers of a language follow a natural order of language learning that is the same for different L1 speakers. To limit this question to the domain of our investigation, we determine whether a difference exists in the rank order of the phonology between Korean speakers and Chinese speakers for learning English coda obstruents. In other words, we expect that the first language does not influence the development of non-native phonology.

Studies on cross-linguistic strategies used in producing interlanguage sounds involve common adaptation strategies of insertion and deletion in relation to recoverability and markedness, among others. Here, "recoverability" means that segments can be deleted if the listener can easily recover the underlying representation; "markedness" means that an unmarked member is considered to be simpler, more basic, and more natural than the less widely occurring marked member.

Recoverability in the development of non-native codas was studied by Abrahamsson (2003) in relation to consonant deletion and vowel epenthesis by Chinese learners of the Swedish language. His participants tend to add a vowel to the final consonant without deleting any original segments so that the target form is recoverable; especially when the intended phonemes of the word list are unrecoverable (or unpredictable) from other elements in the context. This preference of epenthesis to deletion in non-native speech is supported by other studies as well (Kim, 2009 for Korean EFL leaners; Davidson, 2006 for English learners of pseudo-Czech words; Lin, 2001 for Chinese EFL learners).

It is important to note that both insertion and deletion in non-native phonology produce an unmarked form of syllable, a CV syllable. The insertion rules in non-native phonology demand the insertion of a vowel after a consonant, but never the reverse case, of a consonant after a vowel, to form a CV structure of the syllables. Likewise, deletion rules in non-native phonology demand deletion of the final consonant, but never of a vowel, which may also form the CV structure of the syllables. The markedness constraints of a syllable structure state that a CV syllable is least marked; a voiceless coda stop is less marked than the voiced counterpart; a stop consonant is less marked than the fricatives in a syllable coda; and a simple coda with a single consonant is less marked than a complex coda with consonant clusters (Eckman, 1977, 2004; Jakobson, 1962). When applying this to our domain of investigation, Chinese syllables are the least marked because they usually consist of a CV structure, Korean syllables are moderately marked because they allow only one consonant in the coda position, and English syllables are most marked because they allow many complex codas. Therefore, the adaptation to L2 English syllables by our L1 Chinese and Korean speakers involves a developmental change from a less-marked form to a more-marked counterpart. The natural order hypothesis predicts that a feature change to substitute one coda consonant by another (more-marked form) will be acquired later than an insertion or deletion resulting in a CV syllable (less-marked form).

Integrating the issues of recoverability and markedness, the prediction for the natural order of non-native phonology is deletion < insertion < substitution, which applies no matter what the learners' native language is.

1.4. Research Questions

The research question concerns the developmental order of non-native phonology for learning more marked English monosyllables by Korean and Chinese learners, whose native languages have a less marked syllable structure. The question, therefore, consists of three parts: natural order, learnability, and markedness universals.

1) Will different groups of learner proficiencies show the same order of phonological adaptation?
2) Will the same phonological rule be applied to both L1 and L2 words?
3) Will the speakers of different L1s show the same order of phonological adaptation?

The first question on developmental order is answered 'no' if any single group of learner proficiency shows different ranking orders of adaptation compared to any other proficiency group of the same L1 and L2. If this occurs for any single group, then we will not be able to claim a natural order of non-native phonology.

The second question, on learnability, is answered 'no' if a group of learners applies two different phonological rules: one to L1 words and the other to L2 English words. For example, an L1 Korean learner may apply a coda-stopping rule to L1 Korean words for *ray* as in /pitʃʰ/ [pit], and the vowel epenthesis rule to L2 English word *beach* as in /pitʃʰ/ [pitʃʰi].[2] If this occurs, it is evidence against language transfer, whereby non-native speakers did NOT transfer their L1 phonology to L2 production.

The third question is answered 'no' if the order of non-native phonology in L1 Korean L2 English speech differs from that in the L1 Chinese L2 English speech. For example, L1 Korean learners tend to epenthesize a vowel rather than delete the final consonant in the L2 English word *beach,* as in /pitʃʰ/ [pitʃʰi], while L1 Chinese learners may prefer the deletion over insertion, as in *beach* /pitʃʰ/ *[pi].[3] If this occurs, then non-native phonology has no natural order. The natural order of language learning is expected to be the same across different L1 speakers. Thus, both L1 Korean and L1 Chinese learners in this hypothetical example would prefer epenthesis over deletion to produce *beach* /pitʃʰ/ [pitʃʰi], but not *[pi].

2. EXPERIMENT 1: KOREAN ENGLISH

Experiment 1 investigates if there is a natural order of development in non-native phonology for learning English monosyllables by Korean learners (Research question 1). If so, we further question whether the same phonological rule is applied to both L1 and L2

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[2] [b] and [p] are bound allophones of the same phoneme /p/ in the Korean phonology.
[3] [b] and [p] are allophones of the same phoneme /p/ in Chinese phonology, as in Korean language.

words by Korean speakers (Research question 2), and whether the developmental order is the same for Chinese learners in Experiment 2 (Research question 3). Thus, Experiment 1 leads us to answer all our research questions.

2.1. Participants

Fifty one Korean learners of English living in Korea participated in this study. Their language proficiency was measured by a standardized test, the Test of English for International Communication (TOEIC, henceforth) by the Educational Testing Service (ETS). Based on the TOEIC score and other equivalent test scores, learners were divided into three proficiency groups as shown in Table 1.[45]

TABLE 1

Korean Learner Subjects by Proficiency Group Based on TOEIC Score

	M (SD)	Range (Min/Max)	Number of Subjects (Male/Female)
High Level	864 (81.0)	760 – 990	13 (8/5)
Middle Level	647 (70.3)	520 – 755	29 (12/17)
Low Level	365 (91.9)	280 – 515	9 (2/7)
Total	612 (198.2)	0 - 990 possible	51 (22/29)

The subjects were a homogeneous group of Korean-speaking English learners who were undergraduate students in Korea with no difficulty in hearing or speaking. The Korean language was native to all learners, and English was learned as a foreign language. The average age of the participants was 20.0, with a maximum age difference of 7 years.[5] The learners had all received the standard formal English education of Korea, from the age of 9 on through undergraduate study. The average number of years of learning English was 11 years. Mostly, their English pronunciations were intelligible. Some had studied in an English-speaking country, which might be reflected in their proficiency score on the TOEIC.

In addition to Korean-speaking English-learner participants, subjects included 20 native English speakers[6]: 12 as a control group of speakers, 11 as native English listeners (three of these participants for both roles of speaking and listening). They included 9 males and 11 females, with a mean age of 23. The subjects were recruited based on the qualification that English was their main language during childhood and their best language. Depending on time availability, L1 English listeners rated one to four sets of a total of six sets of L2

[4] Eleven learner subjects presented their TOEIC scores, and others had different ways of placing their proficiencies in terms of other scores (e.g., the TOEFL score, or the pre-test score of a pronunciation class). The proficiency groups were divided based on the can-do guide from the ETS research report (Powers, 2010, pp. 7-8).

[5] The age is projected from their educational background and other biological information.

[6] Eighteen of these native English speaker subjects were from University of Southern California and served the roles of speaking and listening; while the remaining two were from Kangwon National University and served as native listeners. Inter-rater reliability did not differ by region.

English productions by L1 Korean that were mixed and randomized with L1 English. Each set was rated by seven people on average, and each rater spent about 30 minutes to rate each set. The native speaker participants were allowed to work for a minimum of 30 minutes to a maximum of 2 hours, with a short break after each set.

2.2. Speech Materials

The speech materials consisted of 12 monosyllabic words, made of singleton coda obstruents permissible only in English, not in Korean: /b/, /d/, /g/, /f/, /v/, /θ/, /ð/, /s/, /z/, /ʃ/, /tʃ/, and /dʒ/. These 12 obstruents are the exclusive list of coda obstruents that occur only in English, not in Korean, of all 21 coda consonants permissible in English, as listed in Section 1.2.[7] Table 2 shows the minimal pair of word lists for the learner production data.

TABLE 2
Monosyllabic English Words Used to Collect Production Data from Korean Learner Speech

Phoneme	Test Word	Minimal Pair of Comparable Words	
		L1 Form (L1 Rule)	Other Form
b	cab	cap (Devoicing)	cav
d	mad	mat (Devoicing)	
g	sag	sack (Devoicing)	
f	cuff	cup (Stopping)	
v	leave	leap (Stopping)	leaf
θ	bath	bat (Stopping)	bass
ð	bathe	bate (Stopping)	bade
s	mass	mat (Stopping)	mash
z	buzz	but (Stopping)	bus
ʃ	wish	wit (Stopping)	we, wis, wishy
tʃ	witch	wit (Stopping)	we, witchy, wits
dʒ	wedge	wet (Stopping)	wed, wedgy, weds

In Table 2, the test words and their corresponding minimal pair of words are presented, if the L1 Korean rule applies. For example, the word *cab* will be devoiced in coda to become *cap* by the coda-devoicing rule in Korean: All lenis stops are voiced intervocalically, but are voiceless in a word-final coda. On the other hand, the stopping rule in Korean codas applies to all oral

[7] The consonant /ʒ/ does not occur either initially or finally in native English syllables, but only in foreign origin words, usually in French: *beige, massage,* and *rouge*. There are many English speakers who cannot pronounce final /ʒ/ and may substitute the closest native English sound, which is /dʒ/ (Reed & Levis, 2015, p. 38).

fricatives[8] and affricates to a voiceless plain stop as in the following Korean words: /pis/ [pit] 'comb'; /pitʃ/ [pit] 'debt'; /pitʃʰ/ [pit] 'ray.' All words in Table 2 are controlled to be familiar to the learners to enable them to read without significant assistance.

2.3. Data Collection

The learner production data were acquired in a sound lab in a Korean university to record only one person at a time in a quiet environment. Each participant was asked to sit at a table with a microphone. The instructions were given in the Korean language.

Prompts given to the subjects contained 25 English words with corresponding pictures that were randomized within each group of three to four words. The 25 words consisted of the 12 test words and 13 filler words to disguise the purpose (refer to examples in Appendix). The learners were asked to state the word for each picture by referring to the words written in one line above the picture. Learners were told that, if a word was unknown to them, they could ask the recording assistant about the meaning. The learners were allowed to repeat a reading if they wished. The learner participants spent approximately ten minutes each to complete the task. The recordings generated one or two long audio files per speaker. We then separated these long audio files of utterance into short audio files of each word, in order to randomize the ordering of the recorded words for the following listening evaluation by native English speakers. As a result, we obtained 572 audio files of test words produced by Korean-speaking English learners (51 learners*12 test words - 40 missing audio = 572 word files of Korean-speaking English learners).[9][10]

2.4. Analysis

The audio files of L2 English words spoken by L1 Korean learners were grouped according to each test word of English and were then randomized within each group. The audio files were then presented to native English listeners using a stimulus presentation program.[10] The native English listeners were asked to choose one of six choices on a computer screen that incorporated the Korean phonology of codas, as shown in Table 3.

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[8] Among fricatives, /h/ does not undergo this stopping rule, but causes the following onset plain consonant to be aspirated, as in /tʃohta/ [tʃotʰa] 'good.'

[9] One word *leave* was recorded by only 11 people, because the word was later inserted in the recording list.

[10] "Paradigm Stimulus Presentation," available at www.paradigmexperiments.com.

TABLE 3

List of Choices for L1 English Listeners to Evaluate L2 Production by L1 Korean Speakers

Phoneme	Forced Choice List for Native Speaking Listeners of English					
	1 Deletion	2 Correct	3 Insertion	4. L1 form Substitution	5. Other Substitution	6
b	ca[ ]	cab	cab[a]	cap	cav	None of these
d	ma[ ]	mad	mad[a]	mat	ma[the]	
g	sa[ ]	sag	sag[a]	sack	sa[dge]	
f	cu[ ]	cuff	cuf[a]	cup	cu[v]	
v	Lee	leave	leave[a]	leap	leaf	
θ	ba[ ]	bath	bas[a]	bat	bass	
ð	ba[ ]	bathe	bath[a]	bait	bade	
s	ma[ ]	mass	mas[a]	mat	mash	
z	bu[ ]	buzz	buzz[a]	but	bus	
ʃ	we	wish	wishy	wit	wis	
tʃ	we	witch	witchy	wit	wits	
dʒ	wed	wedge	wedgy	wet	weds	

In Table 3, the correct form of a given word is listed as an option along with other options, including a vowel insertion, coda deletion, and the comparable minimal pair of words that applied to the L1 Korean rules. These comparable word lists were taken from Table 2. All choices were randomized for each audio presentation on a computer screen, so that the listeners would not be able to find the correct form in the same expected place on the choices' display. Inter-rater reliability among native English listeners was good: On average, 83.2% agreement was obtained for learner speech (*N*=4,423 ratings) as the experimental group and 96.0% agreement for native speech (*N*=598 ratings) as the control group.[11] From these multiple ratings, we calculated single result per speaker per word based on the largest number of agreements by our multiple raters. We obtained 678 evaluation results of test words that consisted of 546 experimental data for L1 Korean L2 English speech and 132 control data for L1 English speech.

2.5. Results

The results showed that Korean learners used the same order of acquisition strategies: substitution > insertion > deletion. More importantly, the error rate (that is, the proportion of erroneous production) decreased as the learner proficiency increased.

[11] We used the simplest form of the reliability measure based on percent agreement, calculated as the number of agreement scores divided by the total number of scores for each word-level production data. This is to give intuitive understanding for our non-statistician readers and to caution that our cases of missing data (because of missing production or missing rating) may not be compatible with some statistic methods. Kappa statistics or Cronbach's alpha is not appropriate for our data, because we have nominal variables of adaptation strategies (inappropriate for Cronbach's alpha) and multiple layers of data (audio files of multiple words read by multiple subjects) evaluated by different subsets of multiple raters (inter-rater heterogeneity).

FIGURE 1

L2 Coda Production by Korean Learners as Perceived by Native-English Listeners (N = 678)

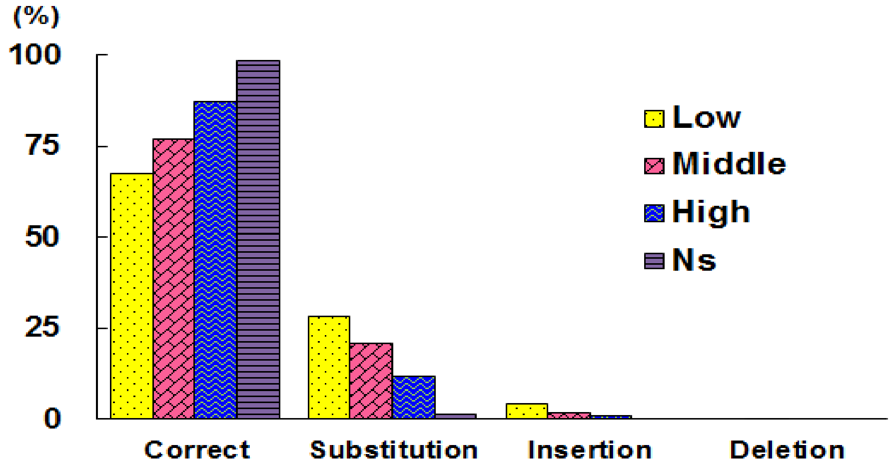

Figure 1 shows the overall distribution of strategies used by each level of Korean learners. The order of strategies used by each level of learners is the same. The percentages of substitution, insertion, and deletion are 28.2%, 4.2%, and 0% for low-level learners, 20.7%, 1.9%, and 0.3% for middle-level learners, and 11.6%, 1.1%, and 0% for high-level learners, respectively. The frequency counts for each choice for each level of Korean learners are given in Table 4.

TABLE 4

L2 Coda Production by Korean Learners as Perceived by Native English Listeners

Proficiency Level	L2 Coda Production of Korean Learners				
	Correct	Substitution	Insertion	Deletion	Total
Low	96 (67.6%)	40 (28.2%)	6 (4.2%)	0 (0%)	142 (100%)
Mid	238 (77.0%)	64 (20.7%)	6 (1.9%)	1 (.3%)	309 (100%)
High	83 (87.4%)	11 (11.6%)	1 (1.1%)	0 (0%)	95 (100%)
Total	417 (76.4%)	115 (21.1%)	13 (2.4%)	1 (.2%)	546 (100%)

A one-way goodness-of-fit chi-square was conducted to find out whether L1 Korean learners of L2 English have a specific pattern of errors across all the different levels. As shown in Table 4, substitution is the most frequent error type by Korean-speaking English learners, and the frequency order of the error type is the same regardless of their proficiency levels: Substitution > Insertion > Deletion (Low: χ^2 (1, N = 46) = 25.13, p < .001. Mid: χ^2 (2, N = 71) = 103.63, p < .001. High: χ^2 (1, N = 12) = 8.33, p = .004).

An additional finding was that the error type was sensitive to the types of coda phonemes, as shown in Table 5.

TABLE 5

L2 Coda Production by Korean Learners According to Phoneme Type

Phoneme	Forced Choice List for Native Speaking Listeners of English						
	1. Deletion	2. Correct	3. Insertion	4. L1 form Substitution	5. Other Substitution	6. None of These	Total
b	0 (0%)	13 (25%)	0 (0%)	35 (69%)	1 (2%)	2 (4%)	51 (100%)
d	0 (0%)	39 (76%)	0 (0%)	11 (22%)	0 (0%)	1 (2%)	51 (100%)
g	0 (0%)	38 (75%)	0 (0%)	11 (22%)	0 (0%)	2 (4%)	51 (100%)
f	0 (0%)	38 (75%)	0 (0%)	9 (18%)	3 (6%)	1 (2%)	51 (100%)
v	0 (0%)	10 (91%)	0 (0%)	1 (9%)	0 (2%)	0 (0%)	11 (100%)[12]
θ	1 (2%)	32 (63%)	0 (0%)	0 (0%)	18 (35%)	0 (0%)	51 (100%)
ð	0 (0%)	47 (92%)	0 (0%)	0 (0%)	1 (2%)	3 (6%)	51 (100%)
s	0 (0%)	47 (92%)	1 (2%)	0 (0%)	0 (0%)	3 (6%)	51 (100%)
z	0 (0%)	38 (75%)	0 (0%)	4 (8%)	7 (14%)	2 (4%)	51 (100%)
ʃ	0 (0%)	49 (96%)	1 (2%)	0 (0%)	1 (2%)	0 (2%)	51 (100%)
tʃ	0 (0%)	48 (94%)	3 (6%)	0 (0%)	0 (0%)	0 (0%)	51 (100%)
dʒ	0 (0%)	39 (76%)	7 (14%)	1 (2%)	1 (2%)	3 (6%)	51 (100%)
Total	1 (0%)	417 (76%)	13 (2%)	76 (14%)	39 (7%)	26 (n/a)	572 (n/a)

In Table 5, stops, sibilants, and other fricatives show different behaviors. The voiced stops /b,d,g/ in the words, *cab, mad*, and *sag*, are replaced by voiceless stops /p,t,k/ that conform to L1 phonotactics. The native English listeners identified the L2 productions as the unintended words, *cap, mat*, and *sack*. The voicing difference is not phonemic, but allophonic variation in Korean phoneme inventory. Unlike these cases of stop sounds, insertion occurred only for the sibilant sounds, /s, ʃ, tʃ, dʒ/, in *mass, wish, witch*, and *wedge* (shaded numbers in Table 5). The native English listeners identified these L2 productions as the unintended forms of vowel insertion, **massa, wishy, witchy*, and *wedgy*. The resulting forms are well-formed Korean syllables, because sibilants are allowed only in the onset position, not in codas. This L2 rule is different from L1 rule, because by L1 rule in Korean phonology final sibilants become stops, as in *mat, wit, wit,* and *wet*, respectively (See Table 2 for L1 Korean form of substitution). The rest of the fricatives in Table 5, /f, v, θ, ð, z/ are not present in the Korean phonology, either as phonemes or as bound allophones.

It is also interesting to observe that there was no insertion into a final consonant of the English words, *cab, mad,* and *sag,* by Korean learners, which could have resulted in [kæbə], [mædə], and [sægə]. This learner phonology is different from loanword phonology, because Koreans write the English word *mad* as [mædə] in the Korean alphabet, always with the additional vowel at the end. Other familiar loanwords with /b,g/ as in *rib* and *dog*, also show additional vowels that Koreans write in the Korean alphabet [ribə] and [dogə].

[12] This word is later introduced to have only 11 subjects to record their L2 productions, as we reported previously in Section 2.3.

3. EXPERIMENT 2: CHINESE ENGLISH

Experiment 2 answers Research questions 1 and 3. We investigate if there is a natural order of development in non-native phonology for learning English monosyllables by Chinese learners (Research question 1). If so, we shall further investigate Research question 3 to see whether the developmental order is the same as in Experiment 1 for Korean learners. Research question 2 is not applicable for Chinese learners, who do not have a coda obstruent in L1 words to compare with L2 words.

3.1. Participants

A total of 66 Chinese learners of English living in China participated in this study. Their language proficiency groups are based on the College English Test (CET), a national English test used in the People's Republic of China. Based on the CET score, learners were divided into three proficiency groups as shown in Table 6.

TABLE 6
Chinese Learner Subjects by Proficiency Group Based on CET Score

	*M (*SD*)*	Range (Min/Max)	Number of Subjects (Male/Female)
High Level	560 (37.2)	510 – 590	19 (2/17)
Middle Level	452 (19.6)	430 – 459	35 (4/31)
Low Level	395 (31.8)	320 – 429	12 (0/12)
Total	455 (61.8)	0 - 710 possible	66 (6/66)

Low level was assigned to the learners who scored less than 430. This is the minimum score required for university students in China to earn a bachelor's degree if they are not English majors. High level is assigned to those who scored 510 and above, because this is the score of the 55% national ranking of test takers in China, which was reached by 18% of our subjects.[13]. The scores between 430 and 509 represent passing the exam with basic ability in English.

All the subjects were a homogeneous group of Chinese-speaking English learners, who were non-English-major undergraduate students in China with no difficulty in hearing or speaking. The Chinese language was the native language for all learners, who also learned English as a foreign language. All learners were able to speak Mandarin Chinese, the language in which the instruction was given for this experiment.

[13] Another possible grouping for high-level learners is the score of 550 and above, which is the level eligible for the national speaking test in China. Our subjects included only four students in this range, of all 66 participants, which rendered this grouping unreliable for our research. The scores 430 and 510 are the national ranking of 17% and 55%, respectively (*College English Test Band 4 and Band 6*, www.cet.edu.cn, Retrieved on January 28, 2018).

The average age of the participants was 19.4, with a maximum age difference of 2 years. The learners had received the standard formal English education of China, from age 12 and on through undergraduate study. Generally, their English pronunciation was intelligible. None of our subjects had studied in an English-speaking country.

In addition to Chinese-speaking English learner participants, the subjects included 15 native English speakers, 9 of whom also participated in Experiment 1, evaluating the L1 Korean productions of L2 English depending on their time availability. All of these subjects were recruited from a US college, based on the qualification that English was their main language during childhood and their best language. They included 4 males and 11 females, with a mean age of 22. Of these 15 subjects, 10 were a control group of speakers, 11 were native English listeners (6 of these participants for both roles of speaking and listening). Each L1 English listener evaluated one to four sets of a total of six sets of L1 Chinese L2 English productions that were mixed and randomized with L1 English productions; each set took 30 minutes on average. None worked for more than two consecutive hours, including a short break after each set.

3.2. Speech Materials

The speech materials consisted of 16 monosyllabic words, made of singleton coda obstruents permissible only in English, but not in Chinese: /t/, /d/, /p/, /b/, /k/, /g/, /f/, /v/, /s/, /z/, /θ/, /ð/, / ʃ /, /ʒ /, /tʃ/, and /dʒ/. These 16 obstruents are the exclusive list of coda obstruents that are permissible only in English, but not in Korean, of all 21 coda consonants permissible in English. Table 7 shows the near minimal pair of word lists for the learner production data.

TABLE 7

Monosyllabic English Words Used to Collect Production Data of Chinese Learner Speech

Voiceless		Voiced	
Phoneme	Test Word	Phoneme	Test Word
p	pup	b	pub
t	bat	d	bad
k	dock	g	dog
f	leaf	v	leave
θ	teeth	ð	teethe
s	course	z	cause
tʃ	rich	dʒ	ridge
ʃ	rush	ʒ	rouge

Table 7 presents the pair of test words that contrast the voicing feature in the coda position. All these stops are impermissible in Chinese phonology; learners thus need to choose an adaptation strategy to pronounce them. Possible adaptation strategies are to insert a vowel after a coda stop to make it at a permissible onset stop in Chinese phonology, or to delete the coda stop to retain only the part of the syllable permissible in Chinese phonology, or to change the sound to result in a different meaning for the minimal paired words. In this regard, Chinese is an interesting language to use in testing the natural ordering hypothesis: Is the preference of strategies in a fixed order regardless of learner proficiency? All words in Table 7 were controlled in a familiar context that learners would be able to read without much assistance.

3.3. Data Collection

The learner production data were acquired in a sound lab in a Chinese university, recording only one person at a time in a quiet environment. Each participant was asked to sit at a table with a microphone. The instructions were given in Mandarin Chinese.

The prompts printed on one page were given, which contained 16 test words in randomized order. The randomization was adopted in order to disguise the pairing of words by voiced and voiceless contrasts in the coda position. When reading the word list, learners were told to articulate the test words individually by leaving an audible pause (approximately one or two seconds) between each word. The learners were allowed to repeat a reading if they wished to correct a pronunciation mistake. The learner participants spent approximately ten minutes each to complete the task. The recordings generated one or two long audio files per person, which were separated into word-level audio files. As a result, we obtained 1,018 audio files of test words, each of which contained only one word produced by one learner per file (66 learners*16 test words - 38 missing audios = 1,018 word files of Chinese-speaking English learners).[14]

3.4. Analysis

The audio files of the L2 English words spoken by L1 Chinese learners were grouped according to each pair of voiced and voiceless test words of English, randomized within each group, and then presented to native English listeners by the same stimulus presentation software as that used in Experiment 1.[15] Therefore, the native listeners were unaware of the word intended by the learner. The native English listeners were asked to select one of five choices on a computer screen that presented both forms of correct and substitution words, along with the deleted and inserted forms, as shown in Table 8.

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[14] Missing audio files were largely caused by the subjects' mistakes of not reading some words, or reading different words. A few cases had bad data because of wrong audio format.

[15] "Paradigm Stimulus Presentation," available at www.paradigmexperiments.com

TABLE 8
List of Choices for L1 English Listeners to Evaluate L2 Production by L1 Chinese Speakers

Phoneme	Forced Choice List for Native Speaking Listeners of English				
	1. Deletion	2. Correct or Substitution	3. Insertion	4. Correct or Substitution	5. Insertion
b / p	pu[ ]	pub	pub[a]	pup	pup[a]
d / t	ba[ ]	bad	bad[a]	bat	bat[a]
g / k	do[ ]	dog	dog[a]	dock	dock[a]
v / f	Lee	leave	leave[a]	leaf	leaf[a]
ð / θ	tea	teethe	teethe[a]	teeth	teeth[a]
z / s	cau[ ]	cause	caus[a]	course	cours[a]
dʒ / tʃ	ri[ ]	ridge	ridge[a]	rich	rich[a]
ʒ / ʃ	ru[ ]	rouge	rouge[a]	rush	rush[a]

In Table 8, the pairs of voiced and voiceless words are presented in the same group in randomized order, and the listeners were forced to choose among the minimal pairs of words or the forms of deletion or insertion. These comparable word lists are taken from Table 7. All choices were randomized for each audio presentation on a computer screen, the play order of which was also randomized, so that the listeners would not be able to find the correct form in the same expected place on the choice list. The inter-rater reliability among native English listeners was good: Average agreement was 82.4% for learner speech (N = 7,526 ratings) as the experimental group and 90.8% (N = 304 ratings) for English native speech as the control group. From these multiple ratings, we calculated single result per production data based on the largest number of agreements by our multiple raters. We obtained 1,176 evaluation results of test words produced by both Chinese-speaking English learners and native English controls (1,018 learner data + 158 native English control data).

3.5. Results

The results showed that Chinese learners also used the same order of acquisition strategies: substitution > insertion > deletion. However, the Chinese results slightly differed from the Korean, because the error rate decreased slowly as the learner proficiency increased. In other words, the learners of lower proficiency did not differ greatly from the higher-level learners in the proportion of erroneous production.

FIGURE 2

L2 Coda Production by Chinese Learners as Perceived by Native English Listeners (N = 1,176)

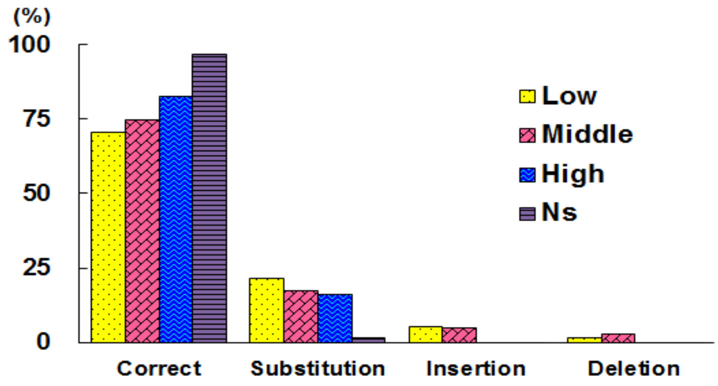

Figure 2 shows the overall distribution of strategies used by the Chinese learners at each level. The order of strategies used by each level of learners was almost the same. The percentages of substitution, insertion and deletion were 21.5%, 5.6%, and 2.0% for low-level learners, 17.5%, 4.9%, and 2.9% for middle-level learners, and 16.2%, 0.6%, and 0.6% for high-level learners, respectively. The results showed only a slight decrease of error rates along with the increase of learner proficiency, perhaps because most learners in our study did not practice speaking, because their proficiency level was below the eligible score (550) for the speaking test in China. Another possible reason is that none of our Chinese subjects had stayed in an English-speaking country for more than one month, unlike our Korean subjects. The frequency counts for each choice for each level of the Chinese learners are given in Table 9.

TABLE 9

L2 Coda Production by Chinese Learners as Perceived by Native English-Speaking Listeners

Proficiency Level	L2 Coda Production of Chinese Learners				
	Correct	Substitution	Insertion	Deletion	Total
Low	214 (70.9%)	65 (21.5%)	17 (5.6%)	6 (2.0%)	302 (100%)
Mid	410 (74.7%)	96 (17.5%)	27 (4.9%)	16 (2.9%)	549 (100%)
High	138 (82.6%)	27 (16.2%)	1 (0.6%)	1 (0.6%)	167 (100%)
Total	762 (74.9%)	188 (18.5%)	45 (4.4%)	23 (2.3%)	1018 (100%)

A one-way goodness-of-fit chi-square was conducted to find out whether L2 English learners of L1 Chinese have a specific pattern of errors across all the different levels. As shown in Table 9, substitution is the most frequent error type by Chinese-speaking English learners, and the frequency order of the error type is the same regardless of their proficiency levels: Substitution > Insertion > Deletion (Low: $\chi^2(2, N = 88) = 67.11$, $p < .001$. Mid: $\chi^2(2, N = 139) = 81.17$, p < .001. High: $\chi^2(2, N = 29) = 46.62$, $p < .001$).

An additional finding was that the error type was sensitive to the types of coda phonemes, as shown in Table 10.

TABLE 10

L2 Coda Production by Chinese Learners According to Phoneme Type

Phoneme	Forced Choice List for Native Speaking Listeners of English						
	1. Deletion	2. Correct	3. Insertion & Substitution	4. Insertion	5. Substitution	Missing Audio	Total
b	0 (0%)	39 (59%)	0 (0%)	5 (8%)	18 (27%)	4 (6%)	66 (100%)
p	1 (2%)	53 (80%)	2 (3%)	0 (0%)	10 (15%)	0 (0%)	66 (100%)
d	0 (0%)	47 (71%)	0 (0%)	6 (9%)	9 (14%)	4 (6%)	66 (100%)
t	0 (0%)	56 (85%)	0 (0%)	2 (3%)	8 (12%)	0 (0%)	66 (100%)
g	0 (0%)	48 (73%)	0 (0%)	5 (8%)	8 (12%)	5 (8%)	66 (100%)
k	0 (0%)	53 (80%)	1 (2%)	0 (0%)	11 (17%)	1 (2%)	66 (100%)
v	8 (12%)	46 (70%)	0 (0%)	4 (6%)	4 (6%)	4 (6%)	66 (100%)
f	0 (0%)	54 (82%)	0 (0%)	1 (2%)	11 (17%)	0 (0%)	66 (100%)
ð	1 (2%)	29 (44%)	1 (2%)	3 (5%)	28 (42%)	4 (6%)	66 (100%)
θ	0 (0%)	54 (82%)	0 (0%)	1 (2%)	11 (17%)	0 (0%)	66 (100%)
z	2 (3%)	53 (80%)	0 (0%)	4 (6%)	3 (5%)	4 (6%)	66 (100%)
s	1 (2%)	20 (30%)	1 (2%)	0 (0%)	44 (67%)	0 (0%)	66 (100%)
dʒ	0 (0%)	49 (74%)	0 (0%)	2 (3%)	10 (15%)	5 (8%)	66 (100%)
tʃ	0 (0%)	53 (80%)	1 (2%)	0 (0%)	11 (17%)	1 (2%)	66 (100%)
ʒ	10 (15%)	44 (67%)	0 (0%)	5 (8%)	2 (3%)	5 (8%)	66 (100%)
ʃ	0 (0%)	64 (97%)	0 (0%)	1 (2%)	0 (0%)	1 (2%)	66 (100%)
Total	23 (2.2%)	762 (72.2%)	6 (0.6%)	39 (3.7%)	188 (17.8%)	38 (3.6%)	1056 (100%)

In Table 10, the voiced obstruents /b,d,g,v,ð,z,dʒ,ʒ/ in the words, *pub, bad, dog, leave, teethe, cause, ridge,* and *rouge*, invariably show a higher rate of insertion (shaded numbers) than their voiceless counterparts /p,t,k,f,θ,s,tʃ,ʃ/ in the words, *pup, bat, dock, leaf, teeth, course, rich*, and *rush*. This contrasts to the Korean case, in which insertion occurred only for the sibilant phonemes in L1 phonology /s, ʃ, tʃ, dʒ/. Although Chinese syllables disallow neither voiced or voiceless obstruents, the Chinese speakers seemed to treat the voiced and voiceless phonemes of English differently.

4. DISCUSSION

4.1. Natural Order of Non-native Phonology

The first research question was whether the same pattern of non-native phonology exists across proficiency levels. Our research results showed that the same pattern exists. The results in Figures 1 and 2 from our two experiments on L1 Korean and L1 Chinese learners showed that the order of non-native phonology is the same across proficiency levels: substitution > insertion > deletion. This in turn supports our main proposal of the presence of a natural order of non-native phonology. Our results also confirm the previous findings including Kim (2009), suggesting that insertion is more frequent than deletion in non-native phonology.

Further clarification of the concept of natural order is that our order of adaptation proportion is not the same as the chronological acquisition order or difficulty order as suggested in prior literature on the natural order (Krashen, 1981, p.54; Abrahamsson, 2003, p.341). The chronological order of learning stages that learners undergo is not deletion, insertion, then substitution (feature change), nor do they feel more difficulty in the same order: deletion < insertion < substitution. For example, the L2 form of the English word *witch* /wɪʧ/ always appears with an insertion *witchy* /wɪʧi/, never with a deletion *we* /wɪ/ or a feature change *wit* /wɪt/. This is true across the beginning, intermediate, and advanced learning stages and across the low, mid, and high proficiency levels. This does not mean that the previous literature is incorrect, but that previous arguments were based on erroneous L2 forms as evidence that the target form was not acquired. In contrast, our research presented L2 types, not forms, as evidence that the learners had not acquired the class of phonemes in the given phonetic environment.

4.2. Learnability of L2 Phonology: Recoverability over Transfer

The second part of our research question is concerned with whether the same phonological rule is applied to both L1 and L2 words. Our research results in Table 5 show that our Korean learners applied different phonological rules to the L1 and L2 words. The L1 rule of coda stopping in L1 Korean words of /pis/ [pit] ‘comb,’ /piʧ/ [pit] ‘debt,’ and /piʧh/ [pit] ‘ray,’ did not apply to the L2 English words of *mass*, *wish*, and *witch* that showed the L2 rule application of vowel insertion, *massa* [mæsə], *wishy* [wɪʃi], and *witchy* [wɪʧi]. It is important to note that L1 rule application to L2 words would have produced a different English word *mat* [mæt] for the intended word *mass*, or a different word *wit* [wɪt] for the intended word *witch*. The learners are fully aware of these phonemic differences /s, ʃ, ʧ, t/ because they are also phonemic in L1 Korean. On the other hand, the L1 allophonic rule applied as in the cases of coda devoicing, which changed the intended word *cab, mad*, and *sag* into *cap, mat,* and *sack.* This rule of coda devoicing happens to be reported in Cantonese learners’ production of English voicing contrasts (Eckman, 1981). Cantonese has no voiced coda in L1 forms as in Korean.

There exist non-transfer errors, as noted by Selinker (1972) and others; that is, errors are also caused by universals or developmental factors, which are similar or identical to those occurring in L1 acquisition. The factor for our L2 rule of insertion is recoverability where an L1 rule would derive unrecoverable information (undesired). The L1 rule of coda stopping changes to different phonemes from /s, ʧ, ʤ/ to /t/ in both L1 Korean and L2 English phoneme inventories, while the L2 rule of insertion does not.

The results of this study suggest that recoverability is higher ranked in non-native phonology than transfer. For Korean phonology in Table 2, the application of coda stopping will cause information loss, making the L2 word unidentifiable: *mass, wish, and witch* become *mat, wit*, and *wit*, respectively, by the L1 rule of coda stopping. We recall that our learner subjects did not apply this rule to their L2 English. To clarify further, our data shows that L1 Korean learners did not produce erroneous L2 forms of /mæt/ or /mæ/, but only /mæsə/ for the English word *mass*. Learners avoid the L1 rule if the rule application brings phoneme change or segmental loss because they fully recognize the difference by their L1 phoneme inventory. Non-native phonology of substitution is mainly used for allophonic changes of learners' L1, as in the English word *cab* [kæp] produced by L1 Korean learners, whose L1 has [b] and [p] as allophones of the same phoneme /p/.

Further clarification of the concept of the L1 role of transfer is that native-language listeners are not very sensitive to erroneous forms if they do not change the meaning. Native listeners did hear the accent, but tended to choose correct or incorrect meaningful forms rather than inserted or deleted nonsense forms in their list of forced choices. This was found in our own examination of the same learner speech data by acoustic transcription. The authors and the acoustically-trained assistants transcribed all data through a spectrographic analysis using the software WaveSurfer.[16] Native listeners perceived far more substitution but less insertion than the acoustic transcription showed (21% vs. 7% for substitution and 2% vs. 3% for insertion for L1 Korean; and 18% vs. 11% for substitution and 5% vs. 8% for insertion for L1 Chinese). The deletion rating was low in both perception and acoustic transcriptions (0% vs. 1% for L1 Korean; and 2% vs. 2% for L1 Chinese), although acoustic transcription of word-final stops is not to be taken reliable due to indistinctness from a subsequent silence signal of pause. What these results mean is that the native language transfer is not as problematic for native listeners of the target language, unless the meaning changes. Nevertheless, different phonological rules apply to L1 and L2 words, as judged by both native listeners and the acoustic transcriptions.

4.3. Universals of Non-native Phonology: Recoverability Over Markedness

The third research question was whether the pattern of non-native phonology is the same for both L1 Korean and L1 Chinese learners. Our research results confirm that they are same. The results in both Figures 1 and 2 invariably show the same pattern of the non-native phonology of L2 English (substitution > insertion > deletion) regardless of whether the learners' L1 is Korean or Chinese. Of these, two types of non-native phonology (adaptation strategies) support the suggestion of universal markedness. As pointed out in previous discussions, insertion and deletion rules in non-native phonology always result in an unmarked form of CV syllables.

A further clarification was made in our previous discussion for why the number of insertion forms was greater than that of deletion forms of L2, even though both forms

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[16] We also used other speech analysis software, Audacity and Praat, to crosscheck the sound visualization by WaveSurfer.

would equally result in unmarked CV syllables. This was found to be due to the recoverability of information by insertion, but not by deletion. Deletion is the least common non-native phonology because learners risk the loss of information and cause communication troubles by deleting sounds. When the resulting form is equally unmarked, i.e., CV syllables, then non-native phonology will prefer insertion to deletion because of further advantages of recoverable information.

Preference for insertion and avoidance of neutralization are the main characteristics of non-native phonology, in contrast with native phonology. For native phonology, as shown in Table 2, neutralization is common due to the functional need of the speakers to minimize the articulatory effort, provided the speech is intelligible. On the other hand, for non-native speakers, speech intelligibility is lower, and speakers thus avoid deletion or neutralization and relinquish reducing their articulatory effort.[1718]

5. CONCLUSION

In this study, non-native phonology showed a natural order that applies across proficiency levels for both L1 Chinese and Korean learners acquiring L2 English coda obstruents. Three interesting findings were reported.

First, non-native phonology operates in a fixed rank order of proportion: substitution > insertion > deletion. This rank order is proposed to be "natural" because the same pattern is present regardless of the learner proficiency or the learners' native language.

Second, the results of the research show that the natural order is specific in its coverage only to the extent of different native languages and different proficiency groups, but excludes the scope of chronological acquisition order or cross-sectional difficulty order, unlike other previous studies in which all these different scopes were confused. Our research results were valid only for different L1s and for different proficiency groups, but not for the time sequence that learners undergo from one stage to the next, and not for the difficulty rank where one L2 form is more difficult to acquire than the compared forms. This suggests that "natural order" must only mean a fixed rank order that may or may not be the same as the difficulty order or acquisition order, and future work must clarify the coverage of these three different scopes of the natural order (rank order, difficulty order, and acquisition order).

Third, the factors for this natural order of non-native phonology are recoverability, transfer, and markedness, of which recoverability surpasses transfer or markedness when these factors compete with each other. The winning competition was proposed based on two reasons: Insertion is preferred to deletion; and L1 neutralization is avoided in L2 forms. Deletion and neutralization generate fewer marked forms but lose recoverable information.

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[17] Kim (2009) shows that L2 sentential production also prefers insertion to deletion as in L2 word production.

The avoidance of L1 rules in our results limits previous claims of L1 transfer, and none of our subjects applied L1 rules of coda stopping that would neutralize different L1 phonemes in their coda positions (e.g., /s/ becomes /t/ in the coda).

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APPENDIX

Sample Picture Test used to Elicit L2 English Production Data by L1 Korean Speakers

Following are the sample pictures that were used to elicit the coda production data from Korean-speaking English learners. There were 25 words and the corresponding pictures in the test sheet in randomized order in groups of three to four words each. These words contained 12 test words and 13 filler words to hide the purpose of the test. The test words were *cab, mad, sag, cuff, leave, bath, bathe, mass, buzz, wish, witch,* and *wedge*; the filler words were *cap, mat, sack, cup, bat, but, rouge, wit, wet, shore, shawl, near,* and *kneel*. The learners were asked to say the word for each picture by referring to the word list above each line. Learners were allowed to ask the test administrator about the meaning of words in the list.

Application levels: Tertiary

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Received on December 1, 2017
Reviewed on January 15, 2018
Revised version received on January 30, 2018