

# Non-native Acquisition of Phonotactic Constraints: A Study of English Pronunciation by Korean Learners\*

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**Kim, Jong-mi. (2015). Non-native Acquisition of Phonotactic Constraints: A Study of English Pronunciation by Korean Learners. *The Linguistic Association of Korea Journal* 23(4), 91-113.** A principled basis for the non-native acquisition of phonotactics is proposed in light of the phenomena that Korean native speakers adapt to the foreign phonological well-formedness of English as the target language of learning. We discuss five types of phonotactic adaptation, namely, avoidance of neutralization, avoidance of assimilation, preservation of contrasts, progressive assimilation, and a preference for insertion over deletion. Of these five types, progressive assimilation has been little reported in literature, and newly tested in this study by means of production and perception experiments as well as a spectrographic analysis. It is concluded that the principles of enhancement and faithfulness predict the phonotactic adaptation in non-native speech and the overlap principle lends little.

**Key Words:** non-native acquisition, phonotactics, Korean English, avoidance of assimilation, progressive assimilation, enhancement, faithfulness

## 1. Introduction

The principles of non-native adaptation of phonotactic constraints that are

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being proposed herein are referred to as enhancement and faithfulness. The term “phonotactic constraints” refers to the ways of stating which sequences of segments may occur in specific parts of a syllable in a given language (Carr 2008: 34). For instance, the onset sequence /pn/ violates English phonotactic constraints. *Phonotactics* is a general term for the principles of phonological well-formedness in a particular language (Hayes 2009: 64). A *constraint* is a formal characterization of a structure that is illegal in a particular language.

The process of enhancement adds motoric instructions to phonological input to enhance the perceptual saliency of the jeopardized sounds as a consequence of non-nativeness (cf. Keyser and Stevens 2006). The enhancement gestures appear to be faithful to target phonology. Faithfulness in phonology means that every input sound must have a corresponding output sound which is identical and in the same position (Hancin-Bhatt 2008: 122). Learners’ acquisition of a new language entails a process of re-ranking faithfulness constraints from the native language rankings to those in the target language (Broselow, Chen and Wang 1998).

There are many disagreeing views on the non-native production processes (Eckman 2004), although it has been agreed to some extent that the output sound sequence in non-native speech gets interference from the phonology of the learners’ native language (Broselow 1984; Flege and Wang 1989; Altenberg 2005). We demonstrate in this paper how the disagreements are resolved in terms of enhancement and faithfulness.

We discuss five types of non-native phonology in the production of English words by native speakers of Korean:

1. Avoidance of neutralization
2. Avoidance of assimilation
3. Preservation of the contrasts
4. Progressive assimilation
5. Preference of insertion over deletion

In order to observe how these non-native phonology phenomena enhance perceptual saliency and keep faithful to the target language, we administered a phonetic experiment on native and learner speech. The experiment was

comprised of 1) production of English words by native speakers of Korean, 2) a listening evaluation by native speakers of English, and 3) a spectrogram analysis of a sound sequence that involves phonotactic constraints.

The organization of this paper is as follows. Section 1 introduces the research goal and scope. Section 2 outlines the concepts of enhancement and faithfulness as well as the phonotactic constraints in English and Korean. Section 3 presents examples of non-native phonotactics that manifest enhancement and faithfulness. Section 4 describes a phonetic experiment involving the evaluation of non-native speech by native listeners and a spectrographic analysis. Section 5 discusses what the experimental results indicate in relation to faithfulness and enhancement in non-native phonotactics.

## 2. Backgrounds

### 2.1. Enhancement in Phonology

The process of enhancement adds motoric instructions to phonological input to enhance the perceptual saliency of the jeopardized sounds. (cf. Keyser and Stevens 2006: 33). For example, in certain Southern Central Australian languages, Arabana, Aranda, and WaNgaNuru, medial nasal consonants /m/, /n/, and /n/ in post-stress position are produced with a brief obstruent interval at the time of consonantal closure. This phenomenon is called PRESTOPPING. By doing this, nasalization is postponed until the consonantal closure is complete, so that the formant transitions are more distinctive and hence the distinctions between places of articulation for the consonant are perceptually more salient. The result of this postponement is to enhance place distinction for the post-stress, medial consonants.

Keyser and Stevens (2006:37) also discuss the opposite cases where speakers overlap adjacent gestures that reflects a universal tendency to conserve time and energy. For example, the coarticulation of /nb/ in *teen bag* occurs by means of gestural overlap, in which the labial closure is formed during the time when there is an alveolar closure for /n/.

Of these two universal speech principles that enhance perceptual saliency on the one hand, and the overlap gestures to conserve energy on the other, we will, in later sections, demonstrate that only enhancement, and not overlap is the principle that governs non-native phonology.

## 2.2. Faithfulness

Faithfulness is a basic type of universal constraint in Optimality Theory that ensures congruence between input and output forms (cf. Hancin-Bhatt 2008: 122, and many others). Examples are the constraints called Max-IO, Dep-IO and Ident-IO that rule out deletion, insertion, and sound change correspondingly.

## 2.3. Non-native Phonotactics

In the process whereby non-native speakers produce foreign words, the learner is forced to resolve the difference in phonotactic patterns of the target language as well as the speaker's native language. This is because phonotactic constraints vary from one language to another in accordance to the language specific restrictions on the permissible sequence of sounds that can occur in a given position in a syllable. For instance, the Korean utterance of the English word *strike* may end up with [suturairku], which has five syllables, since onset sequences such as /str/ do not conform to the phonotactic constraints of Korean that disallow any complex onset or coda.

The occurrence of such interference of native phonotactic constraints seems to have general agreement in literature (Broselow 1984, Flege and Wang 1989). The interference by native phonotactic constraints appears in the speech of advanced learners who know well the phonotactic constraints of the target language (See Altenberg 2005 for English learned by Spanish native speakers).<sup>1)</sup>

On the other hand, our focus in the present study is the discrepancy between the phonotactic adaptation process of non-native speech that differs from either the native phonology or the target phonology. For example, the

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1) Altenberg (2005) reported that advanced Spanish-speaking learners of English continued to transfer the syllabification constraints of Spanish in producing word-initial consonant clusters in English, although these learners demonstrated perceptual awareness of the relevant phonotactic constraints in English.

English word *bus* violates Korean phonotactics that disallow a fricative in a syllable coda position. The native lexicon *beos* ‘friend’ is pronounced as [pʌtʰ], while the foreign word *bus* is pronounced as [pʌsʰw]. The following section presents five groups of such discrepancies in phonotactic adaptation. We purport to interpret the discrepancy in terms of the principles of enhancement and faithfulness in non-native speech.

- (1) Difference in phonological well-formedness of English and Korean
  - a. Onset phonotactics
    - English: CCC
    - Korean: C
  - b. Coda phonotactics
    - English: CCCC
    - Korean: C among /m,n,ŋ,l,p,t,k/
  - c. Sequence phonotactics for nasal assimilation
    - English: [oral stop] [nasal stop]
    - Korean: \*[oral stop] [nasal stop],  
but only [nasal stop] [nasal stop] is allowed<sup>2)</sup>
  - d. Sequence phonotactics for liquid gemination
    - English: [lr, rl, nl, ln]
    - Korean: \*[lr, rl, nl, ln], but only [ll] is allowed

Phonological well-formedness in (1) show three groups of phonotactic contrasts between English and Korean. The first contrast in (1a) is onset phonotactics where English allows up to three consonants (e.g., *stray*), while Korean allows only one consonant. The second contrast in (1b) is coda phonotactics where English allows up to four consonants (e.g. *texts*), while Korean allows only one consonant whose phonemic content must be one of the following: /p,t,k,m,n,ŋ,l/. The third type of contrast in (1c) and (1d) are sonorant sequencing phonotactics, because English allows different alveolar sonorants in a row, while Korean allows only /ll/ or /nn/.<sup>3)</sup>

2) The sequence of [oral stop] [nasal stop] is possible as an underlying form, although the surface form in Korean phonology permits only a [nasal stop] before a [nasal stop].

3) The constraint (1c) also allows sequence of non-alveolar nasals, i.e., /nm, mm, mn, ŋm, ŋn/.

Accordingly, these three types of phonotactics were chosen for our research on non-native phonotactic constraints. Using many corollary non-native phonotactic phenomena that are left seemingly disjointed to one another, we demonstrate how enhancement and faithfulness may offer some insights to non-native phonology.

### 3. Evidence from Non-native Phonotactic Constraints

#### 3.1. Avoidance of Neutralization

The first piece of evidence is apparent in avoidance of neutralization. In the example of a Korean learner speaking the English word *bus*, the interfered form of learner speech is [p<sub>AS</sub>sw], while the native phonology would be [p<sub>AT</sub>] as in the Korean word *beos* /p<sub>AS</sub>/ 'friend'. The principles of enhancement and faithfulness intervene as follows.

- (2) Avoidance of neutralization in /b<sub>AS</sub>/ [p<sub>AS</sub>'w] 'bus'
- a. Non-native Korean English: Neutralization does not apply
    - English word: /b<sub>AS</sub>/ [p<sub>AS</sub>'w] 'bus'
    - Phonotactic adaptation: A vowel is inserted
    - [s] is ENHANCED by the insertion of the vowel
    - [s] is FAITHFUL to the target English segment [s]<sup>4)</sup>
  - b. Native Korean phonology: Neutralization applies
    - Korean word: *beos* /p<sub>AS</sub>/ [ p<sub>AT</sub>' ] 'friend'
    - Phonotactic adaptation: /s/ -> [t']
    - [ t' ] loses the perceptual saliency due to no audible release
    - [ t' ] output does not keep the identical phonetic feature of input /s/, and becomes indistinctive from another phoneme /t/

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The velar nasal /ŋ/ occurs only in a syllable coda, but not in a syllable onset.

4) Faithfulness in non-native phoneme content for coda /s/ accompanies enhancement of the sound by vowel insertion as in [sw]. This phenomenon of enhancement is discussed in Section 3.5 in that learners prefer insertion over deletion.

In (2), the English phoneme sequence /pʌs/ violates the Korean phonotactic constraint that disallows a fricative in a coda position as stated in (1b). What is interesting is that the output form [pʌs'ʌ] is a new form that differs from the native form [pʌt'] or the target form [bʌs].

Our model infers that the output form /s/ in learner speech is enhanced by the insertion of the default vowel /ʌ/, and is faithful to the target sound /s/ unlike the native word that ends with /t/. This is a case of enhancement because changing to /t/ would lose the perceptual saliency of the coda /s/ in becoming indistinctive from another phoneme /t/. The phoneme /t/ in Korean is pronounced as [t'] with no audible release in syllable final position, but as [t] with audible release in syllable initial position and as [d] with voicing between sonorant segments.

### 3.2. Avoidance of Assimilation

The second piece of evidence appears in avoidance of assimilation. While native Korean phonology nasalizes an obstruent before a nasal consonant as in /batmægi/ [nm] 'weed,' non-native speech avoids nasal assimilation as in the English words /bætmen/ [tʌm]. The principles of enhancement and faithfulness intervene as described below.

- (3) Avoidance of assimilation in /bætmen/ [bætʌmæn] 'batman'
- a. Non-native Korean English: Assimilation does not apply
    - English word: /bætmen/ [tʌm] 'batman'
    - Phonotactic adaptation: A vowel is inserted
    - /t/ is ENHANCED by the insertion of the vowel
    - [t] is FAITHFUL to the target English segment [t]
  - b. Native Korean phonology: Assimilation applies
    - Korean word: /batmægi/ [nm] 'weed'<sup>5)</sup>
    - Phonotactic adaptation: /t /-> [n]
    - [n] loses the perceptual saliency by consecutive nasal stops

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5) In fast speech, [nm] becomes [mm] as in /batmægi/ [bammægi] [bammægi] 'weed' and /binmal/ [bimmal] 'flummery'.

- [n] output does not keep the identical phonetic feature of input /t/, and becomes indistinctive from another phoneme /n/

In (3), the English phonemic sequence /bætɹmæn/ violates the Korean phonotactic constraint that disallows an oral stop followed by a nasal stop as stated in (1c). The output form [tɹm] in learner speech [bætɹmæn] does not lose perceptual saliency of [t] by not being assimilated to homorganic nasals [nm], and is faithful to the target sound [tm].<sup>6)</sup> Non-native phonotactic adaptation as such behaves differently from native words that change /tm/ into [nm] as in /batmægi/ [nm] ‘weed.’ What is interesting is that the output form [bætɹmæn] is a new form that differs from the native-like adaptation [bænɹmæn] or the target form [bætɹmæn].

Our model infers that the output form [t] in learner speech is enhanced by the insertion of the default vowel [ɹ], and is faithful to the target sound [t] unlike the native word that surfaces as [n]. This is a case of enhancement because changing to [n] would lose the perceptual saliency of the coda /t/ in becoming indistinctive from another phoneme /n/.

### 3.3. Preservation of Phonemic Contrasts

The third piece of evidence is drawn from keeping the phonemic contrast of target phonology. For novice learners, the final [r] deletes while keeping the final [l], as in the words *bar* [ba] and *bell* [bɛl].

#### (4) Preservation of phonemic contrasts in /bar/ [ba] ‘bar’

##### a. Non-native Korean English: Phonemic contrasts maintained

- English word: /bar/ [ba] ‘bar’
- Phonotactic adaptation: /r/ is deleted
- /r/ [ ] is ENHANCED by blocking the neutralization of /r/ and /l/<sup>7)</sup>

6) The inserted vowel [ɹ] is a default vowel of insertion in Korean phonology to meet the phonotactic constraints of Korean syllables (Kim 2009).

7) Otherwise, both /kar/ ‘car’ and /kal/ ‘Carl’ will become the same surface form [ka]. Korean speakers maintain the distinction of two underlying representations by deleting the coda consonant /r/ as in the English word, *car* [ka] and preserving the coda consonant /l/



- The deletion is FAITHFUL to the English phonemic contrast [r, l]
- b. Native Korean phonology: Phonemic contrasts lost by allophony
- Korean word: /bar/ or /bal/ [bal] ‘foot’
  - Phonotactic adaptation: Liquid → l / \_\_\_\_\$
  - Only the allophone [l] is allowed in syllable final position
  - /L/ [r,l] output becomes indistinctive from another English phoneme /l/

In (4), the English phonemic sequence /bar/ violates the phonological well-formedness of Korean that allows the allophone [l], but not [r] in a coda position as stated in (1b). Non-native phonotactic adaptation as such behaves differently from the native words which apply an allophonic rule for coda liquid /bar/ or /bal/ as in [bal] ‘foot’.<sup>8)</sup> What is interesting is that the output form [ba] is a new form that is not from the native form [bal] or the target form [bar].

Our model infers that the output form /bar/ [ba] in learner speech is enhanced by blocking the neutralization of /r/ and /l/, and is faithful to the English phonemic contrast [r, l]. This surface form is unlike the native word that ends with [l] for all coda liquids. This is a case of enhancement because changing to [l] for all coda liquids would lose the phonemic identity of the English coda /r/ in becoming indistinctive from another English phoneme /l/.

### 3.4. Progressive Assimilation

The fourth piece of evidence comes from progressive assimilation (Kim 2013). Speakers choose lawful phonotactic sequence by progressive assimilation, even

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as in the English word, *Carl* [kal]. The coda /r/ may either be deleted or be followed by an epenthetic vowel [u] as in *tar* /taru/. In both cases, the output forms are enhanced by blocking the neutralization of /r/ and /l/, and are faithful to the English phonemic contrast [r, l]. The phonetic realization differs in accordance to the learner proficiency and the speech context. For example, a proficient learner would correctly make the distinction by a rhotic /r/ and a velaric /l/ when reading an English textbook.

8) In a theoretical paradigm of underspecification, the coda liquid is unspecified underlyingly as in /baL/. We represent the forms as in /bar/ or /bal/, for the sake of theory neutral representation.

when regressive assimilation is expected. Progressive assimilation is an attempt for a speaker to be faithful to the sound one by one in the time sequence of pronunciation. According to Korean phonology the sequences of /nl/ and /ln/ are not allowed on the surface, and become [ll] by liquid assimilation. However, developmental transition shows that learners' productions are larger in the order of  $nl > nm > ll$  for /nl/ sequences such as *painless* and  $ln > ll$  for /ln/ sequence such as *illness*. There is no instance of incorrect pronunciation of \*[nn] for *illness* by regressive assimilation.

(5) Progressive assimilation in /peɪnləs/ [nn] 'painless'

a. Non-native Korean English: Preservatory coarticulation

- English word 1: /peɪnləs/ [nn] 'painless'
- English word 2: /ɪlnɪs/ [ll] 'illness'
- Phonotactic adaptation: l → n / n \_\_\_\_
- ENHANCED for the first phone of the pair
- FAITHFUL to the first phone of the pair

b. Native Korean Phonology: Regressive Assimilation

- Korean word 1: /tʃʌnli/ [ ll ] \*[nn] thousand *li* <sup>9)</sup>
- Korean word 2: /tʰwɪni/ [ ll ] \*[nn] dentures
- Phonotactic adaptation: n → l / l \_\_\_\_
- /n/ [ l ] becomes indistinctive from /l/
- /nl/ [ ll ] becomes indistinctive from /nl/ [ ll ]

In (5), the English phonemic sequence /peɪnləs/ 'painless' violates the Korean phonotactic constraint that disallows the sequence of an alveolar sonorant and a liquid sound as stated in (1d). Most learners do not assimilate the sequence /nl/ as discussed in Section 3.1 where learners typically avoid assimilation. This is unlike the native phonology which would make /nl/ into an [ll] geminate. And yet, occasionally the output forms of the [nn] sequence are found in learner speech as in [peɪnnəs]. This is a case of preservatory coarticulation. Preservatory coarticulation blocks the change of /ln/ into [nn]. What is interesting is that the output form [peɪnnəs] 'painless' is a new form

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9) *li* is a measurement unit of distance in Korea.

that is not from the native-like adaptation [peɪlləs] or the target form [peɪnləs].

Our model infers that the output form [nn] in learner speech is enhanced for the first phoneme of the pair and is faithful to the first phoneme of the pair. Such adaptation is unlike the native phonology that surfaces as [l] or [ll]. This is a case of enhancement because changing to [ll] as in native phonology would cause the underlying sequences /nl/ and /ln/ to become indistinctive from each other. Preservation of the first consonant in the target phonology can distinguish the two different underlying sequences.

### 3.5 Preference of Insertion over Deletion

The fifth piece of evidence is that learners prefer insertion over deletion (Kim 2009). According to Korean phonology, onset and coda allow only one consonant as outlined in (1a). The symbol  $\emptyset$  represents ‘null,’ that is, an absence of a segment.

- (6) Non-native Korean English for Insertion in /tæks/ [tæksɯ] ‘tax’
- a. Non-native Korean English: Insertion of a vowel
    - English word: /tæks/ [tæksɯ] ‘tax’
    - Phonotactic adaptation:  $\emptyset$  -> ɯ / CC\_\_\_#
    - s# is ENHANCED by the insertion of vowel
    - Keeping /s/ is FAITHFUL to the target English phoneme [s] than deleting /s/ (The symbol  $\emptyset$  represents deletion.)
  - b. Native Korean Phonology: Deletion of a consonant
    - Korean word: /naks/ [naks] ‘spirit’
    - Phonotactic adaptation: s ->  $\emptyset$
    - A consonant is deleted
    - [s] becomes lost from the sound string of this word

In (6), the English phonemic sequence /tæks/ in the word ‘tax’ violates the Korean phonotactic constraint that disallows an obstruent cluster in a syllable coda as stated in (1b). In (6), learners insert a vowel for consonantal clusters as in *tax* /tæks/ [tæksɯ], although the deletion of a consonant would still obey the phonotactic constraints.

The output form [sw] in learner speech [tæks<sup>sw</sup>] enhances perceptual saliency by the insertion of a vowel. In addition, keeping /s/ is more faithful to the target English phoneme [s] than deleting it. Non-native phonotactic adaptation as such behaves differently from the native words that change /ks/ into [k] as in /naks/ [næk] 'spirit.' What is interesting is that the output form [tæks<sup>sw</sup>] is a new form that is not derived from either the native-like adaptation [tæk] or the target form [tæks].

Our model infers that the output form [s] in learner speech is enhanced by the insertion of the default vowel [u], and is faithful to the target English sound [tæks] unlike the native word that would surface without [s]. This is a case of enhancement because deleting [s] would lose the perceptual saliency of the coda /ks/ by making [s] inaudible. Thus, the cluster /ks/ becomes indistinctive from the single phoneme /k/.

## 4. Experiment on Progressive Assimilation

Of the five types of evidence we presented in the previous section, the fourth type on progressive assimilation has been less explored in the field.<sup>10)</sup> We, therefore, conducted a phonetic experiment of perceptual and acoustic analyses on non-native pronunciation of English words that were produced by Korean native speakers. The learner speech embedded consonantal sequences that involved phonotactic constraints of Korean.

### 4.1. Subjects

There were 68 research subjects in our experiment. The speech of 50 Korean adult learners of English was recorded. The speech of 18 native speaker controls was compared with the non-native speech. Five native speaker raters listened and evaluated the recorded speech. Table 1 summarizes the information for both groups of speakers and the listeners.

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10) This phenomenon of progressive assimilation held the attention and intense discussion of the audience at the conference talk of an earlier version for this work.

Table 1. Subjects' information (native speech, roles, numbers) by group.

	Native Speaker Controls	Learner Speakers	Native Speaker Listeners	Total
No. of Subjects	18	50	5	73

All participants were college educated and their speech contained no noticeable regional accents in their native languages. All speaker participants were in their twenties. None of the learners grew up in an English speaking country. Their proficiency levels varied with the range of mid-low to mid-high, in accordance with their TOEIC listening scores (mean 230, range 125-365 out of total 495 scale). The proficiency levels were divided into four groups of 55 point intervals (125-180; 185-240; 245-300; 305-365<sup>11</sup>); and each group had more or less 21 students.

## 4.2. Speech Materials

Speech materials were the recordings of non-native speakers and native speaker controls reading the following list of sentences. The sentences below include the sequence of /n/ and /l/ in varied order to maintain the same phonetic environment.

### (7) Recording list

- a. *nl* (ten light) / *nr* (ten right) / *nn* (ten night)
- We need **ten light** hats.
  - We need **ten right** hats.
  - We need **ten night** hats.
- b. *nl* (in line)
- I'm waiting **in line** for Bret.
- c. *lr* (all rights) / *ll* (all lights) / *ln* (all nights)
- We counted **all rights**
  - We counted **all lights**.
  - We counted **all nights**.

11) The interval is an increment of 55 points, because the test scores are multiples of the number five. The top range has 60 points interval in order to include all the participants.

d. words<sup>12)</sup>

- **unless** / **only** / **suddenly**
- **illness** / **fullname** / **walnut**

The list above contains a sequence of alveolar sonorants: [n] in sentences (7a) and (7b); and [ln] in (7c). In these sentences, the sequences of [n] and [ln] were put into minimal pairs of words in comparable meaningful contexts. We used the sets of words to ensure the phonetically same environment. This is to exclude the unintended segmental and prosodic variation. We used meaningful context to obtain the natural reading by the speakers and easier recognition by the listeners.

### 4.3. Procedure

The procedure for acquiring the learner speech data consisted of six stages: 1) learners' listening to and repeating native speech one time<sup>13)</sup>, 2) the first recording of production in a quiet room, 3) feedback given to the learners on the first recording, 4) the second recording of production, 5) the native speakers' evaluation of pronunciation tests, and 6) acoustic verification of spectrogram analysis for disagreeing identification of phonemes.

### 4.4. Analysis

Native speakers rated the learner pronunciation of sentences that included the sequence of alveolar nasal sounds.

For analysis, there were four steps in the rating procedure. First, we grouped the same carrier sentences altogether so that the listeners can focus on the variations of the target words.

Second, all the speech data were randomized in terms of speakers and

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12) These word data were recorded and acquired by the author, and have been used in another experiment by Heo (2010). The word data were read speech in isolation form, in sentence contexts and in loanwords. Evaluation methods are different in that Heo had only one rater, while we employ this time 9 raters of phonetic major students from 3 different native language backgrounds.

13) This is to let learners be tested on a heard form of words. Otherwise, a pronunciation experiment on unheard forms may confound the results.

recording times. Thus, speech samples of neither the same speaker nor different speakers were sequenced in any predictable order. This is to prevent the listeners from expecting certain speech samples.

Third, the listeners was forced to make choices among contrasting words, although many L2 productions are marginally or borderline acceptable for the meanings.

Fourth, we conducted a spectrographic analysis for verification of the speech samples when any two listeners had different judgments.

Figure 1 exemplifies the rating screen in the computer.

We need ( \_\_\_ ) ( \_\_\_\_ ) hats.

1 ten night [n n]	2 ten right [n r]	3 ten light [n l]	4 tell light [ll]
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Please click the number above from 1 - 4

Figure 1. Evaluation screen of L2 phonemic quality by native speaker listeners. Native speaker listeners were forced to choose one out of the following four choices in a computer screen after listening to an L2 learner's recorded speech for the given sentence.

In figure 1, the listeners were forced to choose one number out of these four options. All the options consist of real words, and they include the contrasting consonantal phonemes in brackets. Most options are meaningful in the context.

In the case of disagreement between the listeners, we measured the acoustic features by analyzing the spectrogram. To evidence the application of the Korean rule of *l*-alternation, we identified the expected erroneous sounds as

presented in the top four boxes in Figure 1: [nn], [nr], [nl] or [l] for the reading of *ten light*. The learner productions of all three sentences in (7) including *ten light*, *ten right*, and *ten night* were intermixed with native speech, and played in random order. Figure 2 illustrates an incorrectly produced<sup>14)</sup> nasal [n] for the target liquid [l] in non-native English word sequence *ten light*, spoken by a native Korean speaker.

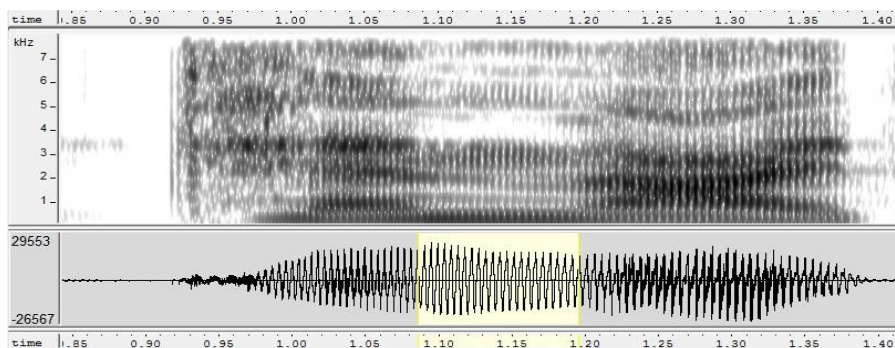


Figure 2. Illustration of an incorrectly produced nasal [n] for the target liquid [l] in L2 English word *ten light* [tɛn naɪt], spoken by a female Korean learner.

Nasal stop sequence is recognized by a very prominent low frequency F1 at about 250 Hz, seen as a dark area in the low frequency region of this spectrogram between 1.09 second and 1.19 second. Nasals in the waveform are highlighted for easier recognition.

#### 4.5 Results of Listening Evaluations on Non-native English Words Produced by Native Speakers of Korean

The results are as follows. Figure 2 shows that the native listeners were accurate in identifying the unassimilated form of non-native production of words that the speaker's native language must assimilate and, at the same time lose the underlying phonemic identity. The rated data in Figure 2 comprises 84 learner speech samples per word, and varied number (22 *all night*, 25 *ten lights*, 49 *in line*) of native speech samples. All 42 learners read the sentences twice

14) All three native listeners incorrectly identified this sample as *ten nights*.



before and after the instruction without exception. All native speech samples were accurately identified as an unassimilated form by the native listeners, although the two groups of native speakers do not know each other. We therefore present only learner speech results in Figure 2.

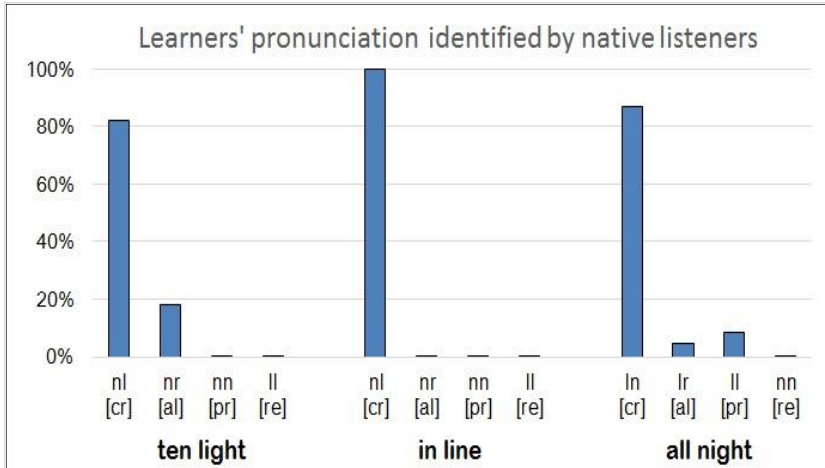


Figure 3. No regressive assimilation appeared in the phoneme sequences of *nl* and *ln* of English produced by Korean native speakers. ( $n=84$  for each word by 42 Korean learners of English). (Note: [cr] = correct, [al] = allophony, [pr] = progressive assimilation, [re] = regressive assimilation)

In Figure 3, listening judgments for phonemic content of words identify few instances of erroneous productions by assimilation, regardless of progressive or regressive type. There are two more interesting facts in the results. First, the results show no regressive assimilation but only progressive assimilation. Thus, the words with the */ln/* sequence as in *all night* show only progressive assimilation */ll/* or */lr/*, but no */nn/* as native phonology would do.

Second, allophony is found to have */r/* in an onset position. Thus, the words with the */nl/* sequence as in *ten light* show */r/* instead of */l/* in the onset position as in *ten [r]ight*. What is even more interesting is the word *all night* which may have to show *all [l]ight* by progressive assimilation, but *al[r]ight* in a few cases.

Progressive assimilation is more obvious within a word, for the reason that phonotactic constraints are the sequence of phonemes as smaller units as a

syllable. Let us consider Figure 4 that rates the /nl/ and /ln/ sequences within a word.

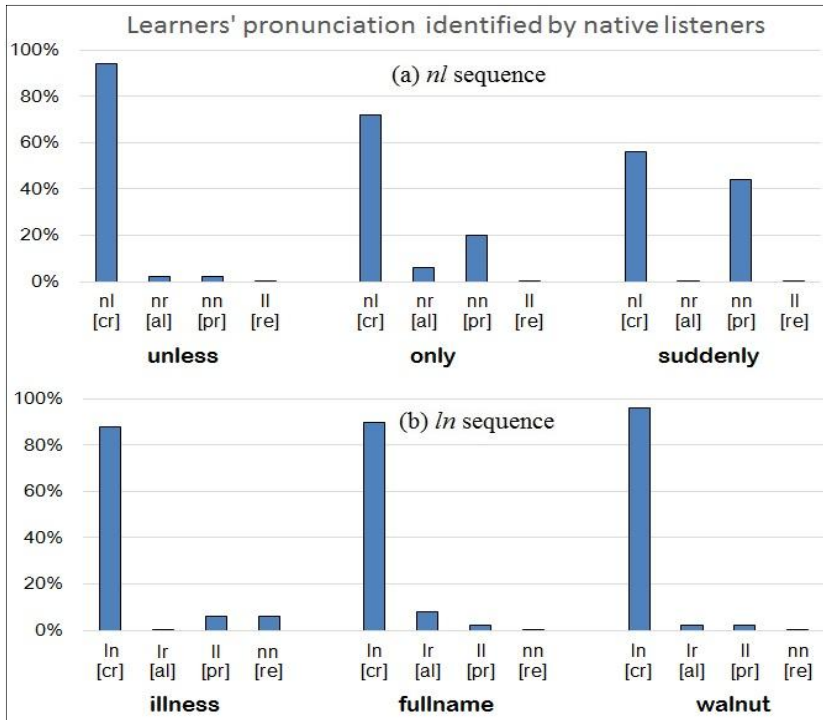


Figure 4. Little regressive assimilation appeared in the phoneme sequences of *nl* and *ln* of English words produced by Korean native speakers. ( $n=50$  for each word by 50 Korean learners of English). (Note: [cr] = correct, [al] = allophony [pr] = progressive assimilation, [re] = regressive assimilation)

In Figure 4, the listening judgments for the phonemic content of words identify few cases of erroneous productions by assimilation: more instances of progressive assimilation, but less instances of regressive assimilation.<sup>15)</sup> Thus, the

15) In our experiment, we tested the words, *in-line* and *on-line* in both loanwords and in sentence contexts. When the word [in line] was read in a sentence context of *We like in-line skates*, the post-test results showed more progressive assimilation. The pretest results showed the production of [nn] 13% and [ll] 88% for 16 learners, while the post-test results showed [nn] 19% and [ll] 3%. If a root and a prefix were combined, then the learners preserved the root phoneme, and changed the affix phoneme for assimilation. Thus, the readers showed more regressive assimilation in the first reading as in i[ll]ine, o[ll]ine. On

words with the /nl/ sequence as in *unless*, *only*, *suddenly* show /nn/, while the words with /ln/ sequence as in *illness*, *fullname*, *walnut* show /ll/. The native phonotactic constraints would result in only /ll/ for all of these words.<sup>16)</sup>

## 5. Discussion and Conclusion

The results indicate that enhancement and faithfulness are underlying principles of non-native speech. The principle of enhancement is demonstrated by the non-native phonotactics that prefers inserting over deleting a segment for a phonologically ill-formed sequence of phonemes. The principle of faithfulness is shown by keeping the phonetic feature of input and avoids assimilation or neutralization.

Five types of evidence are presented from the non-native phonotactics of English by Korean Speakers:

1. Avoidance of neutralization
2. Avoidance of assimilation
3. Preservation of phonemic contrasts
4. Progressive assimilation
5. Preference for insertion over deletion

The consequence of enhancement and faithfulness is lengthened, slower speech with less linking. Lengthened speech is due to vowel insertion. Slower speech is due to less reduction or deletion. Less linking is due to avoiding assimilation. On the whole, the consequences of enhancement and faithfulness are adamant impressions on L2 speech.

The results shed light on theoretical implications for current phonological paradigms. Following is a discussion of the implications on Optimality Theory and Phonological Markedness.

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the other hand, Figures 3 and 4 are simplified versions of the phenomenon that represent the data acquired only from the recording list in (7).

16) Standard pronunciation, Chapter 5, Item 20, by Ministry of Education, Republic of Korea.

### 5.1. Theoretical implication in Optimality Theory

Enhancement and faithfulness render the following three implications in the Optimality Theory framework. First, the constraint Max-IO is preferred over Dep-IO for non-native phonology. In other words, non-native phonotactics renders no deletion, but some insertion. For instance, the English word *tax* renders the surface form [tæksɯ] with an inserted segment for its original sound sequence /tæks/ in the non-native speech by Korean native speakers. The non-native phonotactics of Korean English as such violates the constraint Dep-IO in the Optimality Theory framework that disallows epenthesis. The constraint Dep-IO states that the output segments must have counterparts in the input. This non-native phonotactics of Korean English contrasts to the native phonotactics of Korean phonology that renders a deletion of a consonant instead of insertion of a vowel to prevent a coda cluster. For example, the Korean word /nʌks/ meaning ‘spirit’ renders the surface form [nʌk] with a deleted segment [s], because the underlying form /nʌks/ violates the phonotactic constraint of No Consonant Cluster in a Korean syllable. The Korean word [nʌk] ‘spirit’ is underlyingly /nʌks/ as shown in the affixed word [nʌksi] that contains a nominative case marker *-i*.

Secondly, the constraint Max-IO is compromised with the preservation of phonemic contrast. In other words, non-native phonotactics renders no neutralization due to allophony, but some insertion. For instance, the English word *bar* renders the non-native surface form [ba] with a deleted segment for its original sound sequence /bar/ in the non-native speech by Korean native speakers. The non-native phonotactics of Korean English as such violates the constraint Max-IO in the Optimality Theory framework that disallows deletion. The constraint Max-IO states that the output must preserve all segments in the input. This non-native phonotactics of Korean English contrasts to the native phonotactics of Korean phonology that would neutralize the consonant [r] to the phoneme /l/ that comprises the allophones of [l] in syllable coda, [r] in syllable onset, and [ll] for geminates. For example, the Korean word for the meaning ‘foot’ renders the surface form [bal] with a neutralized segment of the unspecified underlying liquid form [L] in its underlying word form /baL/. As a result, the phonological well-formedness constraint of native speech of Korean

renders the surface form [baʌ] that is different from the non-native surface form [ba] from what would essentially be the same underlying form /baʌ/.

Thirdly, the constraint Ident-IO(F) is obeyed prior to the constraint Dep-IO by preserving the phonological feature by inserting a vowel that would block the assimilation among adjacent consonants. In other words, non-native phonotactics renders no assimilation among adjacent consonants, but instead, insertion of a vowel. For instance, the English word *batman* renders the surface form [bætʌmæn] with an inserted vowel in its input sequence of phonemes /bætʌmæn/ in the non-native speech by Korean native speakers. The non-native phonotactics of Korean English as such violates the constraint Dep-IO for the sake of Ident-IO(F) in the Optimality Theory framework that disallows any feature changing or substitutions. The constraint Ident-IO(F) states that corresponding output and input segments share a feature [F]. This non-native phonotactics of Korean English contrasts to the native phonotactics of Korean phonology that would assimilate the consonant /t/ to the following phoneme /m/ to render the homorganic nasal [n] in the surface phonetic sequence [nm]. For example, the Korean word for the meaning 'weed' renders the surface form [banmægi] with a nasalized segment [n] from the underlying word form /batmægi/. As a result, the phonological well-formedness constraint of native speech of Korean renders the surface form [nm] that is different from the non-native surface form [tʌm] from the same underlying form /tm/.

## 5.2 Theoretical implication in Phonological Markedness

Enhancement and faithfulness render the implication in Phonological Markedness that enhancement is more important than markedness. For example, the marked phonetic feature [+tense] is chosen over the unmarked segment [t] in the non-native speech of the English word *bus*. The English sound sequence /bas/ is pronounced as [pʌsʌ] with the marked phonetic feature [+tense] in the non-native speech by Korean learners. The underlying form violates the native phonotactic constraint that disallows any fricative consonant in coda. The non-native surface form [pʌsʌ] of Korean English as such contrasts to the native surface form *beos* [pʌt] in the Korean word meaning 'friend'. In the native speech of Koreans, speakers change the illegitimate coda /s/ to the unmarked

segment [t] for the underlying form /pʌs/ that violates the native phonotactic constraint. As a result, the phonological well-formedness constraint of the native speech of Koreans renders the unmarked surface form [pʌt], which is different from the non-native marked form [pʌs'ʌ] from the same underlying form /ʌs/.

## References

- Altenberg, E. (2005). The judgment, perception, and production of consonant clusters in a second language. *International Review of Applied Linguistics*, 43, 53-80.
- Broselow, E. (1984). An investigation of transfer in second language phonology. *International Review of Applied Linguistics*, 22, 253-269.
- Broselow, E., Chen, S. & Wang, C. (1998). The emergence of the unmarked in second language phonology. *Studies in Second Language Acquisition*, 20(2), 261-280.
- Carr, P. (2008). *A Glossary of Phonology*. Edinburgh University Press.
- Eckman, F. R. (2004). From phonemic differences to constraint rankings: Research on second language phonology. *Studies in Second Language Acquisition*, 26, 513-549.
- Flege, J. E. & V. Wang. (1989). Native phonotactic constraints affect how well Chinese subjects perceive the word-final English /t/-/d/ contrast. *Journal of Phonetics*, 17, 299-315.
- Hancin-Bhatt, B. (2008). Second language phonology in optimality theory. In J.G. Hansen Edwards & M.L. Zampini (Eds.), *Phonology and Second Language Acquisition*. Amsterdam/Philadelphia: John Benjamins.
- Hayes, B. (2009). *Introductory Phonology*. Malden, MA: Blackwell Publishing.
- Heo, Y-J. (2010). Assimilation rules apply progressively in L2 speech: The case of Korean liquid rules in English words. *Proceedings of the 15th International Conference of Pan-Pacific Association of Applied Linguistics*. Hanyang Women's University, Seoul, Korea. August 17-19. pp. 287-292.
- Keyser, S. J. & K. N. Stevens. (2006). Enhancement and overlap in the speech chain, *Language*, 82(1), 33-63.

- Kim, J.-M. (2009). Insertion preferred to deletion in learner speech: A study of Korean English. *Jungang Journal of English Language and Literature*, 51(3), 101-124.
- Kim, J.-M. (2015). Enhancement and Faithfulness in Non-native Phonology. Presented at the CUNY Phonology Forum Conference on Multilingual Phonology. City University of New York. January 15-16.

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