

## Non-native acquisition of phonological features: Evidence from Korean and English consonants\*

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**Kim, Jong-mi. 2015. Non-native Acquisition of Phonological Features: Evidence from Korean and English Consonants.** *Studies in Phonetics, Phonology and Morphology* 21.1. 57-78. The interplay between contrastive and allophonic features in language learning is investigated in terms of the consonantal features of aspiration and voicing in the English words produced by native Korean speakers in comparison with Korean words produced by native English speakers. Aspiration is a phonemic feature in Korean but allophonic in English, while voicing is a phonemic feature in English but allophonic in Korean. To do this, the English words *trainer*, *drainer* and *strainer* were produced by 42 native Korean speaker learners, while the Korean words *tteoyo*, *deureoyo*, and *teogiya* were produced by 26 native English speaker learners of Korean. Then, these non-native speech productions were recorded and played for evaluation by native speaker listeners. The results have shown that the listeners identified more instances of *strainer* as \**trainer* than \**drainer*, and *tteoyo* as \**deoyo* than as \**teoyo* before instructions, but more as \**teoyo* than as \**deoyo* after instruction. The results indicate that learners do not have an acquisition order among the phonemic features of the target language and their native language. In concrete, the L2 English speakers used the L2 voicing feature rather than the L1 aspiration feature in learning the English word *strainer*, while the L2 Korean speakers used the L2 aspiration feature before instruction and the L1 voicing feature after instruction to learn the Korean word *tteoyo*. These results do not support the views in literature that non-native acquisition is dependent upon L1 phonological features with possible re-ranking due to proficiency increase (Hanchin-Bhatt and Bhatt 1997), nor that an L2 phonological feature that is phonemic in the target language and allophonic in the native language is more easily acquired compared to the case where the L1 phonological feature is phonemic in the native language and allophonic in the target language (Han 2009). On the other hand, the results are compatible to the views in literature that the phonological features in the native language facilitate the acquisition of L2 phonemes (Brown 2000) and that the phonological features in the target language plays no role in the acquisition of L2 phonemes (Flege and Port 1981). (Kangwon National University)

Keywords: phonological features, L2 phoneme, aspiration feature, voicing feature, English consonants, Korean consonants, English by Korean learners, Korean English, second language phonology

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\* This work was supported by the National Research Foundation of Korea Grant funded by the Korean Government (NRF-2012S1A5A2A01016708). An earlier version of this paper was presented at the CUNY Conference on "The Feature in Phonology and Phonetics," that was held at the university on January 16-18, 2013. The paper has greatly benefited by the generous support from the Department of Linguistics at the University of Southern California, where the author was allowed to run the experiment and use the phonetics laboratory.

## 1. Introduction

Do adult learners more successfully acquire the phonological features of native speech or those of their target language, if the feature defines phonemic distinction only in one language but shows an allophonic distribution in the other language? For example, the feature of aspiration is phonemic in Korean, but allophonic in English, while the feature of voicing is allophonic in Korean, but phonemic in English. Which of these phonological features do learners acquire better if their native language is English and the target language is Korean? Does the same question hold true if the native and target languages are reversed? The goal of this paper is to investigate learnability of L2 phonological features in terms of Korean learner speech of English words and American English learner speech of Korean words.

For practical reasons, we limit the scope of investigation to the interplay between the features of aspiration and voicing. These features are phonemic only in one language and allophonic in the other language. Which of these phonological features do learners acquire better?

### 1.1 Backgrounds

Previous studies have revealed differing views on the questions of the relationship between non-native acquisition and phonological features: Irrelevant, L1 feature dependent, and L2 feature dependent. The first view is that non-native acquisition is irrelevant to phonological features. According to Flege and Port (1981), non-native acquisition of English stop consonants by Arabic learners is irrelevant to phonological features. In the Arabic language, there are phonemes for /b/, /d-t/, and /k/. In other words, the language has the phonological features of [place] and [voicing]. It is therefore expected that the Arabic learners of English should have no problem acquiring the new L2 phoneme /p/ in English by using their L1 phonological features of [place] and [voicing]. They are expected to grasp the phonological nature of /p/ in the target language in that the contrast between /p-b/ is analogous to that between /t-d/ and /k-g/. However, the experimental results have shown that Arabic learners pronounce English /p/ as [b], indicating that phonological features played no role in non-native acquisition of an L2 phoneme.

The second view is that non-native acquisition is dependent upon L1 phonological features. This view has been taken by Brown (2000) in the analysis of L2 English phonemes /l/ and /r/ that are produced by native Japanese and Chinese speakers. The phonological contrast /l-r/ is present in English, but absent in both the Japanese and the Chinese languages. However, the experimental results have shown that the English phonemes [l] and [r] are acquired better by Chinese than Japanese speakers. Brown argues that the reason is because the [coronal] feature is present in Chinese, but not

in Japanese. She claims that perception of the non-native contrasts will improve only if the feature underlying a non-native phonemic contrast is present in the native grammar over the course of the learner's development.

A slightly different version of the second view is that non-native acquisition is dependent upon L1 phonological features, but may be reconfigured to L2 phonological features if the proficiency increases. This view is taken by Hanchin-Bhatt and Bhatt (1997), who argue that the language-dependent error types are a function of the learners' L1 constraint ranking transferred into the interlanguage grammar. They claim that Spanish speakers reveal a different set of coda forms than Japanese speakers as a result of different constraint rankings in their L1 grammar. They state that vestiges of the L1 rankings remain due to their resistance to being reranked (Hanchin-Bhatt and Bhatt 1997: 359), although the rankings are reconfigured over time to more closely reflect the L2.

The third view is that non-native acquisition is dependent upon L2 phonological features (Han 2009; Kim 2013b: 21)<sup>1</sup>. According to Han (2009), a phonemic feature in the target language is more successfully perceived than a phonemic feature in the native language when the given feature is allophonic in the other language. Han conducted a perceptual discrimination experiment on plain and aspirated stops as well as voiced and voiceless stops in the Korean language by the native Japanese speaker learners. The contrast between plain and aspirated stops is phonemic in Korean, but allophonic in Japanese, while the contrast between voiced and voiceless stops is phonemic in Japanese but allophonic in Korean. The discrimination tasks showed that Japanese learners were more successful in discriminating plain and aspirated stops than voiced and voiceless stops in Korean; and they showed great improvement in discriminating phonemes as their general proficiency of Korean increased. However, there was no significant improvement in the discrimination of allophones. Han explains these results in that even the feature in the native language is perceived less successfully if it has no phonological function in the target language.

In summation, previous studies have different views on the issues concerning whether language learning depends on phonological features of being complementary and contrastive. The relationship between non-native acquisition and phonological features is considered to be irrelevant in Flege and Port (1981), to be dependent upon L1 features in Brown (2000), and to be dependent upon L2 features in Han (2009) and Kim (2013b). Other positions include Hanchin-Bhatt and Bhatt (1997) who support the L1 dependent position with possible reranking due to proficiency increase.

<sup>1</sup> Kim (2013b: 21) reports as an additional finding in her study that her learner subjects obeyed the phonological feature [±asp] of L2 rather than the phonological feature [±lateral] of L1. The L1 in this study was the Korean language and L2 was the English language. The disparate results in studies may be resolved by the current paper that acknowledges the use of both features.

## 2. Voicing and aspiration features in Korean and English

The phonological feature [ $\pm$ asp] is phonemic in Korean and brings the meaning difference as in the minimal pair of words *teo* ‘open’ and *deo* ‘more’.<sup>2</sup> The alveolar stop consonant in the first word is [ $+$ asp], while the consonant in the second word is [ $-$ asp]. On the other hand, the feature is allophonic in English as in the consonant /t/ in the words *strain* and *train*, where the phoneme /t/ is aspirated in stressed onset as in the latter word, but not in the former word.

In contrast, the phonological feature [ $\pm$ voice] is contrastive in English and brings the meaning difference as in the minimal pair of words *drain* and *train*. The consonant /d/ in the first word is [ $+$ voice], while /t/ in the second word is phonemically [ $-$ voice]. On the other hand, the feature is complementary in Korean as in as in the words *da* [t] ‘all’ and *joeda* [d] ‘all together,’ where the alveolar stop is voiced between sonorant segments as in the latter word, but not in the former word.<sup>3</sup> These features are outlined below.

### (1) Phonological Features in Korean and English

- a. [ $\pm$ asp]: Contrastive in Korean, Complementary in English  
 Korean words: *ta* /t<sup>h</sup>/ ‘ride’    *da* /t/ ‘all’  
 English words: *train* [t<sup>h</sup>]    *strain* [t<sup>-</sup>]<sup>4</sup>
- b. [ $\pm$ voice]: Contrastive in English, Complementary in Korean  
 English words: *train* /t/    *drain* /d/  
 Korean words: *da* [t<sup>-</sup>] ‘all’    *joeda* [d] ‘all together’

To resolve the discrepancy between previous studies, we will conduct a production and perception experiment in English and Korean consonantal features of aspiration and voicing because these features are contrastive in one language and complementary in the other language. While Han (2009) conducted only perception studies on the non-native perception of the Korean language by the native Japanese speakers, this paper focuses on

<sup>2</sup> In this paper, we will use the Romanized transcription for Korean orthography, slash lines / / to represent phonemes, and square brackets [ ] to represent phonetic forms. For Romanized transcription, we followed the convention in the Official Romanization System (2000, current edition) of Korean. For example, the Korean words here are in Korean alphabet  $\text{테}$  for *teo* ‘open’ and  $\text{더}$  for *deo* ‘more.’ These words are contrastive to another word  $\text{떠}$  for *tteo* ‘float.’

<sup>3</sup> The lenis stop /d/ in *deoyo* is voiced in an inter-sonorant position, but voiceless in the beginning of an accentual phrase or a syntactic word. Examples are *jom deoyo*, ‘little more,’ and *obunman deoyo*, ‘five more minutes.’ For Korean, /b, d, g/ are voiceless unaspirated (or slightly aspirated) lenis plosives syllable initially, but are realized as voiced sounds in intervocalic position (Lee 1999: 122, among others). In casual or fast speech, voicing normally occurs within an accentual phrase, or a syntactic word.

<sup>4</sup> As for the representation [t<sup>-</sup>], it might be argued that it is unnecessary to mark the absence of something, i.e., aspiration. However, such a diacritic is useful for our discussion due to the allophonic feature for an unaspirated plosive, i.e., a non-normal lack of aspiration.

production analysis of both the Korean and English languages by the native speakers of each other's languages.

To answer whether adult learners more successfully acquire L1 features or L2 features, let us exemplify the following cases of contrastiveness in language contexts.

(2) Contrastive Features in Korean and English contexts

a. Test Korean: *mure tteoyo*. 'float in water'

*tteoyo* [-asp -voice] 'float'

*teoyo* [+asp -voice] 'open'

*deoyo* [-asp +voice] 'more'

b. Test English: *I like this strainer*.

*strainer* [-asp -voice]

*trainer* [+asp -voice]

*drainer* [-asp +voice]

In (2a), the Korean word *tteoyo* 'float' in the sentence *mure tteoyo* 'float in water' may be misidentified as *teoyo* 'open' or *deoyo* 'more' by the native speaker listeners depending on the proficiency of non-native speakers. On the other hand, in (2b) the English word *strainer* in the sentence *I like this strainer* may be misidentified as *trainer* or *drainer* by the native speaker listeners depending on the proficiency of non-native speakers.<sup>5</sup>

If the speaker chooses contrastive features in the target language, then the phonological feature would be [aspiration] for Korean words spoken by native English speakers, and [voicing] for English word spoken by native Korean speakers. In this case, the erroneous production in L2 Korean is predicted to be *deoyo* [dʌyo] with the feature [-asp] that is contrastive in Korean. For the same reason, the erroneous production in English is predicted to be *trainer* with the feature [-voice] that is contrastive in English.

If, otherwise, the speaker chooses contrastive features in the native language, then the feature would be [voicing] for the Korean word spoken by native English speakers, and [aspiration] for the English word spoken by native Korean speakers. In this case, the erroneous production in Korean is predicted to be *teoyo* that shares the feature [-voice]. For the same reason, the erroneous production in English is predicted to be *drainer* that shares the feature [-asp].

<sup>5</sup> The words, *strainer*, *trainer*, and *drainer* might be difficult for L1 Korean speakers to learn, because these words contain consonant clusters in the syllable onset position. The Korean language allows only one consonant in syllable onset. Of these three words, the word *strainer* may be more difficult, because the segment /s/ follows another /s/ in the sentence, *I like this strainer*. Native speakers, however, did not have any problem of identifying the native production of this particular word in this particular context (96% correct in our response results as we report in the later section). In other words, sequencing of two /s/ segments does not bring any neutralization effect. Learner problem in this case is our research question.

Therefore, the research questions of this paper aim to find out which of the two predictions are correct.

(3) Research questions

- a. Are there more instances of erroneous pronunciation *deoyo* than *teoyo* for the word *tteoyo* in Korean sentence *mule tteoyo* when produced by native English speakers?
- b. Are there more instances of erroneous pronunciation *trainer* than *drainer* for the word *strainer* in English sentence *I like this strainer* when produced by native Korean speakers?

The answers for these two questions may be “yes” or “no” depending on the choice of phonological features by non-native speakers. If both answers are “yes,” then the result would indicate that the non-native speakers use the contrastive phonological feature of the target language than that of the native language. In this case, the result would suggest that Han (2009) is correct, while Brown (2000) and Hanchin-Bhatt and Bhatt (1997) are incorrect.

If, otherwise, both answers to questions in (3) are “no,” then the result indicates that the non-native speakers use the contrastive phonological feature of the native language than that of the target language. In this case, the result indicates that the previous literature by Han (2009) is incorrect, while Brown (2000) and Hanchin-Bhatt and Bhatt (1997) are correct.

On the other hand, if the answer is “yes” to one of the questions in (3), and “no” to the other, then the result indicates that the non-native speaker production is irrelevant to the contrastive phonological features of the native or the target language. In this case, the result indicates that the previous literature by Flege and Port (1981) is correct, while Brown (2000), Hanchin-Bhatt and Bhatt (1997), and Han (2009) are all incorrect.

For expository purposes, we visualize these predictions below.

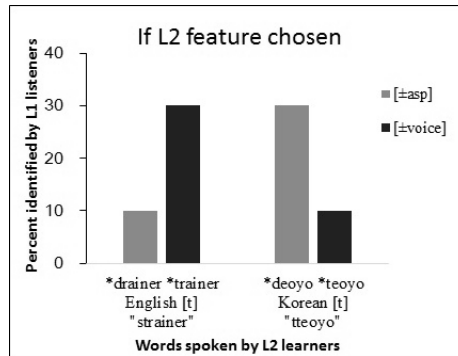


Figure 1. Prediction when L2 feature is chosen by L2 speakers for conflicting phonological features of Korean and English

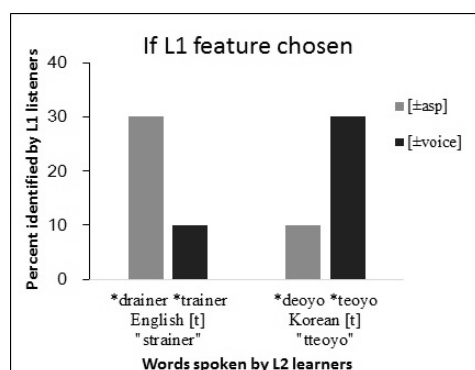


Figure 2. Alternative cases when L1 feature is chosen instead by L2 speakers for conflicting phonological features of Korean and English

Figure 1 represents the case when the L2 phonological feature is chosen by non-native speakers.<sup>6</sup> More erroneous pronunciation *trainer* than *drainer* is expected for the word *strainer* in English sentence, *I like this strainer* when produced by native Korean speakers. For the same reason, more erroneous pronunciation of *deoyo* than *teoyo* is expected for the word *tteoyo* in Korean sentence *mule tteoyo* when produced by native English speakers.

On the other hand, Figure 2 represents the case when the L1 phonological feature is chosen by non-native speakers. More erroneous pronunciation *drainer* than *trainer* is expected for the word *strainer* in English sentence *I like this strainer* when produced by native Korean speakers. For the same reason, more erroneous pronunciation of *teoyo* than *deoyo* is expected for the word *tteoyo* in Korean sentence *mule tteoyo* when produced by native English speakers.

### 3. Methods

#### 3.1 Participants

There were 136 research participants. To see the relationship between phonological and allophonic features in language learning, we collected non-native speech data on consonants from 42 Korean adults learning English and 26 American English speaker adults learning the Korean language. The recorded speech samples were then evaluated for accuracy by 34 native speaker listeners of the two languages: 24 for L2 Korean speech and 10 for

<sup>6</sup> To present as simple a picture as possible, we visualize a case when L2 speakers correctly produced the target sound for 60% of the total productions, and the differences among the comparing productions to be exactly the half of the total erroneous productions.

L2 English speech. We also collected native speech production data from 34 adults as control groups of speakers against which the non-native speech properties were evaluated: 17 for American English and 17 for the Korean language. Ninety four percent (94%) of the native speaker listeners were different from the native speaker controls in the production tasks.<sup>7</sup> Table 1 describes the information for both these learners and the native speaker control group in terms of their native and target speech and the roles.

**Table 1. Speaker Information by group**

Roles	Number (Male/Female)	Mean age	Native Speech	Proficiency (mean/scale)
Learners for L2 English production	42 (16/26)	22.4	Korean	Mid to High (531/990TOEIC)
Ns controls for L1 English production	17 (7/10)	24.9	English	native
Ns listeners for rating L2 English speech	10 (5/5)	36.9	English	native
Learners for L2 Korean speech production	26 (10/16)	24.6	English	Mid to High (71.6/100Listening)
Ns controls for L1 Korean production	17 (6/11)	32.3	Korean	native
Ns listeners for rating L2 Korean speech	24 (9/15)	23.2	Korean	native

Notes: Ns=Native speaker, L1=Native language, L2=Target foreign language

All participants were college educated and had no hearing or speaking difficulty. Most of the learner speakers were in the 18-28 age range. Neither the native speaker control group nor the learners had noticeable regional accents in their own native languages. All learner participants were beyond the level of novice learners, and could read the target language without assistance. We also excluded the learners of near-native proficiency. All non-native speaker participants lived in their home country where their native language was spoken, and where the target language was considered as a foreign language rather than a second language.

### 3.2 Speech materials

Speech materials were the recordings of non-native speakers and the native speaker controls reading the following list of sentences. The reading list is an

<sup>7</sup> One native speaker in English and three native speakers for Korean participated in both the production and the rating tasks. The overlap did not affect the experimental results, because their productions as native speaker controls were equally well identified as being correct by other native speaker listeners.



expansion of the target sentences as outlined in (2): *mure tteoyo* for Korean and *I like this strainer* for English. Sentences below include near minimal pairs of word in that the words differ in one consonantal feature that are contrastive in one language, and allophonic in the other. These words were put into meaningful contexts whenever possible. For each item, a transcript in plain English and the Korean alphabet were presented to the research participants.

(4) Recording list for English sentences

- a. *strainer* [–asp –voice]  
*I like this strainer.*
- b. *drainer* [–asp +voice]  
*I like this drainer.*
- c. *trainer* [+asp –voice]  
*I like this trainer.*

(5) Recording list for Korean sentences

- a. *tteoyo* [–asp –voice]  
물 위에 떠요. *mule tteoyo.*  
‘It floats on water.’
- b. *padatgae* [–asp +voice]  
바닷가에 가요. *padatgae kayo.*  
‘We are going to the beach.’
- c. *deureoyo* [–asp +voice]  
노래 들어요. *norae deureoyo.*  
‘I’m listening to songs.’
- d. *teogiya* [+asp –voice]  
누가 뭐예요? *nugu teogiya?*  
‘Treat to whom is that?’

The list above contains consonants articulated with different phonological features: [–asp –voice] in (4a) and (5a); [–asp +voice] in (4b), (5b) and (5c); and [+asp –voice] in (4c) and (5d). This Korean list contains two voiced consonants between sonorant segments as in (5b) and (5c). This is to ensure the voicing environment of the recorded sentence: i.e., a word medial position in (5b) and an intervocalic position within an accental phrase in (5c).

In order to minimize the undesired influence from prosodic variation, each set of sentences contains the same number of words and word phrases: three words for English sentences and two word phrases for Korean sentences. The prosodic position for English words was the beginning of the third word of each sentence, and the position for Korean words was the syllable onset of non-initial position of each sentence. The test elements were chosen from an open source (Choo and O’Grady 2003) for Korean to facilitate potential cross-checking of data by other researchers.

### 3.3 Procedure

The experimental procedure used on the data acquisition consisted of five stages: 1) listening to the native speaker production of the recording list 2) the first recording of production 3) feedback given to the learners on the first recording 4) the second recording of production and 5) the native speaker evaluation of pronunciation tests.<sup>8</sup> The Korean L2 speech data were taken from the database collected in Kim (2012) and newly rated in 2014 for this research, while the English L2 speech data were acquired in 2013 and rated in 2014. The L2 Korean speech data was collected in the U.S. and rated in Korea, while the L2 English speech data was collected in Korea and rated in the U.S. The location of the data collection was carefully designed to ensure the homogeneous grouping of the native language backgrounds.

For the first stage, the learners first listened to a recorded speech of native model speaker. This was to ensure that learners heard the target form of the pronunciation at least once before they produced the L2 speech. Then the learners had to wait for 10-30 minutes before they proceeded to the next stage: i.e., recording. The time gap was given to prevent the learners from mimicking the pronunciation of the native speaker by working memory.

For the second stage, the learners read the speech materials in (4) and (5) that were mixed with many other filler words and sentences: 49 English fillers and 104 Korean fillers (See Appendix A and B). The fillers were to prevent the learners from knowing what words were actually tested. The native speaker controls read a shorter list of words and sentences with smaller number of fillers: 24 English fillers and 26 Korean fillers. The reading took place in a quiet room, and the read speech was recorded by a trained assistant. Only one person was recorded at a time.

For the third stage, all learners received the feedback on their pronunciation by the instructor (i.e., the author). Only one person (the author) gave all the feedback to ensure the consistency in terms of the type, nature, and amount of the feedback. The feedback concerned some noticeable non-native accents of each person on all the first recordings, including both the test data and the fillers.

For the fourth stage, both the learners and the native speaker controls read again the same speech materials of the first recording. There was a five week time gap between the first recording and the second recording for the learners. The native controls had no time gap. The read speech was recorded in the same way as the first recording. The purpose of the second recording was to give the proficiency variation of the learner production.

For the fifth stage, all recorded data were processed, randomized, and rated for accuracy by native speaker listeners. This was time consuming task, because each person's recording had to be separated into different audio files

<sup>8</sup> The third stage was taken to see if there is a developmental change after feedback. We report the change later in Tables 2 and 3.

by the unit of each test sentence. Such data processing was all done by hand to ensure accuracy. The rating methods are described in detail in the following section.

### 3.4 Analysis

For analysis, native speaker listeners listened to and identified the learner pronunciation of sentences that include minimal pairs of words that differ in one consonantal feature. There were eight steps in the rating procedure. First, we normalized all the speech data in terms of amplitude. This was to prevent the listeners from considering a loud voice as being more proficient.

Second, each test sentence was grouped separately so that the listeners hear the different target words in the same sentence altogether. This was to make the listeners focus on the target consonant embedded in the same speech context.

Third, all the speech data were randomized in terms of speakers and recording times. Thus, the speech samples of the same speaker were not ordered in any predictable order, and different speakers were not ordered in any predictable order. This was to prevent the listeners from knowing the speaker information. If not randomized, for example, speech samples of each speaker might have been paired before and after practice; or the speakers might have been aligned from low to high proficiency. The results would then not have been reliable, by letting the listener to predict what samples would have correct answers.

Fourth, the rating was done by forced choice among contrasting words. This was to prevent the listeners from avoiding decisions, despite the fact that many L2 productions are marginal. The forced choice included the answers, “borderline” and “different sound.”

Fifth, some words were repeated in the rating sequence. This was to see if a given listener returned inconsistent ratings for the same data, i.e., intra-listener variability.

Sixth, the listeners could stop at any time to have a break by pausing the computer program. This was to prevent cognitively overloading listeners with information so that they would not return careless ratings.

Seventh, the rating results were auto-saved in a spreadsheet by a computer program. This was to eliminate an inputting error potentially caused by hand typing.

Eighth, we analyzed inter-listener variability that a listener returns consistently different ratings from the rest of the listeners. We computed the average difference between the ratings of a given listener and that of other listeners.

Figure 3(a) exemplifies the rating screen in the computer. Figure 3(b) is the translation of Figure 3(a).

[CONSONANTS] "누구 (턱, 덕, 떡)이 야?"				
1 잘못 읽음 (ㅌ, ㄷ, ㄸ) 이 아님	2 턱 [ㅌ]	3 덕 [ㄷ]	4 떡 [ㄸ]	5 중간음 [ㅌ=ㄷ=ㄸ]
Please click the number above from 1 - 5				

**Figure 3(a).** Evaluation screen of L2 pronunciation accuracy by native speaker listeners. Native speaker listeners were forced to choose one out of the following five choices in a computer screen after listening to an L2 learner's recorded speech for the given sentence.

[CONSONANTS] <i>nuku (teok, deok, tteok) iya?</i> '(Treat, thanks, rice cake) to whom is that?'				
1 Wrong Reading (Different Sound)	2 <i>teok</i> 'treat' [t <sup>h</sup> ]	3 <i>deok</i> 'thanks' [t]	4 <i>tteok</i> 'rice cake' [t']	5 Borderline Sound [t <sup>h</sup> =t=t']
Please click the number above from 1 - 5				

**Figure 3(b).** Translation of Figure 3(a).

In figure 3(a), the listeners were forced choose one number out of these five options. After this screen was displayed and the recorded L2 speech was played, the listeners clicked the numbers in boxes by a computer mouse. All the options were meaningful in the context, and they were minimal pairs of word with the contrasting consonantal phonemes in brackets. We included the responses in 1 (wrong reading) and 5 (borderline) for all the analysis including inter-listener variability, intra-listener variability, and percentage of the correct responses by listeners.

#### 4. Results

The results are as follows. Figure 4 shows that for our English data the listeners misidentified many L2 production of *strainer* as *\*trainer*, although they did identify correctly L2 production of *drainer* and *trainer*.<sup>9</sup> That is, the

<sup>9</sup> For experimental results, we only see whether the listeners hit the correct responses, or incorrect responses. The misidentification by the listeners may mean either the production mistakes by speakers or the perception mistakes by listeners. We just report the

words *drainer* and *trainer* by the learners were correctly produced, and thereby identified as such by the native speakers. On the other hand, the word *strainer* by the learners were incorrectly produced, and thereby identified incorrectly by the native speakers.

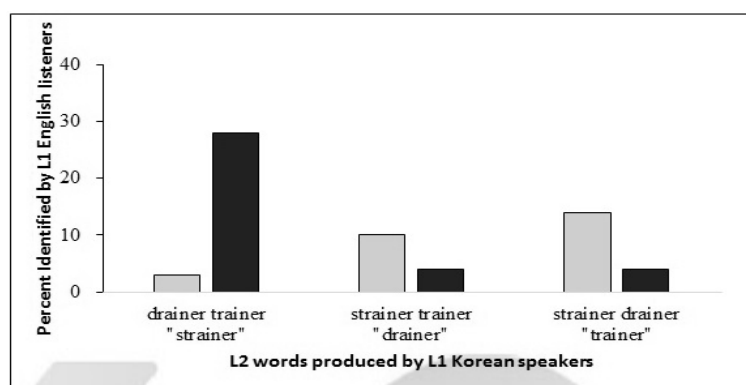


Figure 4. L2 English words produced by L1 Korean speakers and identified by L1 English listeners ( $n=840$  for each word)

In Figure 4, the result for the word *strainer* is predicted from our previous discussion in Figure 1, where the learners had been assumed to use the L2 contrastive feature [-voice] than L1 contrastive feature [-asp]. For other words *drainer* and *trainer*, the learners chose the L2 contrastive feature, so that the listeners identified them correctly. All listeners returned the largest number of identification responses in the same way. The relative ranking among the comparing words in Figure 4 stayed same for the learner productions before and after instruction. In comparison, the L1 production by native speaker controls were correctly identified for 87.3% of the responses by the listeners, as expected.<sup>10</sup> Table 2 shows a total of 2481 responses (42 learners \* 2 times before and after instruction \* 10 native speaker listeners \* 3 words – 39 missing responses by an early leave).

identification rates in percentage, and interpret them as production mistakes. We consider that the perception mistakes were low, because all listeners, without any exceptions, returned the largest number of identification responses in the same way as in Figures 4 and 5, and the listeners correctly identified 93% of the native speech.

<sup>10</sup> For the word *strainer*, native speakers correctly identified the native production for 96% of the responses, as mentioned previously in the introduction section. This word might be considered difficult to produce or identify, because the segment /s/ occurs in a row in our carrier sentence, *I like this strainer*. The full results of identification for native speech were: 95.6% for strainer, 3.6% for drainer, 0.4% for "borderline," 0.4% for trainer, and 0% for "wrong."

**Table 2. Identification scores (%) of L2 English stops produced by L1 Korean speakers.**  
**Correct identifications are given in bold. Scores in parentheses are of the productions**  
**before and after instruction. (n=840 for each word)**

Identification Production	1. Different	2. [t <sup>h</sup> ] <i>strainer</i>	3. [d] <i>drainer</i>	4. [t <sup>h</sup> ] <i>trainer</i>	5 Borderline
/t/ <i>strainer</i> [-asp, -voice]	3 (5→1)	<b>59</b> <b>(70→48)</b>	3 (2→4)	28 (18→38)	7 (5→9)
/d/ <i>drainer</i> [-asp, +voice]	2 (4→1)	10 (10→10)	<b>75</b> <b>(71→80)</b>	4 (7→2)	8 (9→7)
/t/ <i>trainer</i> [+asp, -voice]	1 (0→2)	14 (14→15)	4 (2→6)	<b>74</b> <b>(77→10)</b>	7 (6→8)

The confusion-matrix data in Table 2 show that the L2 English learners produced the unaspirated voiceless stop in *strainer* as aspirated more often than as voiced. On the other hand, aspirated or voiced stops were correctly produced as such. The confusion between the aspirated and unaspirated stop contrasts in native Korean speakers seemingly supports the view that the learners do not use L1 contrastive feature, i.e., [asp], but L2 contrastive feature, i.e., [voice].

A closure look at the data for the learner production before and after instruction, however, present the change from producing the unaspirated voiceless stop in *strainer* as less aspirated *strainer* to more aspirated *trainer*. In other words, the learners increased the use L1 contrastive feature, i.e., [asp] as in *trainer*, although there is no noticeable change in L2 contrastive feature, i.e., [voice] as in *drainer*.

On the other hand, Figure 5 shows L2 Korean language data produced by the native speaker of American English, and rated by Korean native speaker listeners. Korean native speaker listeners misidentified many L2 productions of the alveolar consonant [t'] in the word *teoyo* as \**teoyo* with the aspirated sound [t] and \**deoyo* with the voiced sound. The listeners also misidentified the alveolar consonant [t<sup>h</sup>] in the word *teogiya* as *deogiya*.

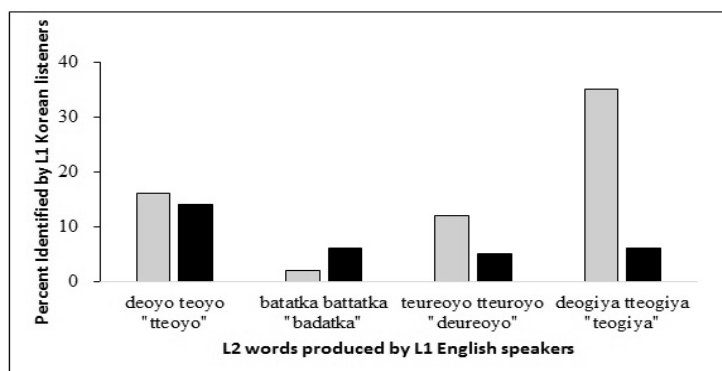


Figure 5. L2 Korean words produced by L1 English speakers and identified by L1 Korean listeners. ( $n=1248$  for each word)

In Figure 5, the result for the word *tteoyo* is not predicted from either Figure 1 or Figure 2, where the learners chose more of one sound than the other among *\*deoyo* and *\*teoyo*. The word *\*deoyo* uses the L2 contrastive [–asp], while the word *\*teoyo* uses the L1 contrastive feature [–voice]. In the same fashion, the learners chose the sound *\*deogiya* that did not use either the L1 contrastive feature [–voice] or the L2 contrastive feature [+asp] for the word *teogiya*. All listeners returned the largest number of identification responses of each word in the same way to show a low inter-speaker variability. L1 production by native speaker controls were correctly identified 99% of the responses by the listeners. Table 3 shows a total of 4992 responses (26 learners \* 2 times before and after instruction \* 24 native speaker listeners \* 4 words – 0 missing responses).

Table 3. Identification scores (%) of L2 Korean stops produced by L1 English speakers. Correct identifications are given in bold. Scores in parentheses are of the productions before and after instruction. ( $n=1248$  for each word)

Identification Production	1. Different	2. asp /t <sup>h</sup> / <i>teogiya</i> <i>teoyo</i> <i>teureoyo</i> <i>batatga</i>	3. lenis /t/ <i>deogiya</i> <i>deoyo</i> <i>deureoyo</i> <i>badatga</i>	4. tense /tt/ <i>tteogiya</i> <i>tteoyo</i> <i>tteureoyo</i> <i>battatga</i>	5 Borderline
/tense/ <i>tteoyo</i> [–asp, –voice]	7 (8→5)	14 (10→18)	16 (23→9)	<b>51</b> <b>(46→57)</b>	18 (13→11)
/lenis/ <i>badatga</i> [–asp, +voice]	7 (5→8)	2 (3→2)	<b>81</b> <b>(83→79)</b>	6 (5→6)	5 (4→5)
/lenis/ <i>deureoyo</i> [–asp, +voice]	5 (6→4)	12 (11→13)	<b>71</b> <b>(72→70)</b>	5 (5→6)	7 (6→8)
/asp/ <i>teogiya</i> [+asp, –voice]	7 (11→3)	<b>42</b> <b>(33→51)</b>	35 (38→31)	6 (7→4)	11 (12→10)

Notes: Lenis consonants are not aspirated or tensed. They are voiced between sonorants, but voiceless otherwise.

The confusion-matrix data in Table 3 show that the L2 Korean learners produced the tense stop in *tteoyo* as lenis as often as aspirated and that they produced the aspirated stop in *teogiya* as neither aspirated or devoiced. In other words, they produced the word *tteoyo* using both L1 feature [–voice] and L2 feature [–asp]. On the other hand, they produced the word *teogiya* as *deogiya* that uses neither L1 feature [–voice], or the L2 feature [+asp].

What is more interesting is the developmental change of the learner production before and after instruction. The tense stop in *tteoyo* presents the change from producing more of the unaspirated stop in *deoyo* to voiceless stop *teoyo*. In other words, the learners increased the use of L1 contrastive feature, i.e., [–voice] as in *teoyo*, and decreased the use of L2 contrastive feature, i.e., [–asp]. The confusion between the voiced and voiceless stop contrasts of L2 Korean by native English speakers does not support the view that the learners increase the use of L2 contrastive feature, i.e., [asp] in accordance to developmental change. Rather, they used both L1 and L2 features, if not used any of the features at all.

## 5. Discussion

All our results in the previous section consistently support the view that there is no acquisition order between the phonological feature that is contrastive in the target language and complementary in the native language and the opposite case where the feature is contrastive in the native language and complementary in their target language. The results negatively answer our research question in (3) for both the English words produced by native Korean speaker learners and for the Korean words produced by native English speaker learners. There were similar amounts of erroneous L2 pronunciations of *deoyo* and *teoyo* for the intended Korean word *tteoyo* in the sentence, *mure tteoyo*, when produced by native English speakers. On the other hand, there were increasingly more erroneous pronunciations of *trainer* than *drainer* after instruction for the intended English word *strainer* in the sentence, *I like this strainer*, when produced by native Korean speakers.

### 5.1 L2 English features *versus* L1 Korean features

Table 4 shows that the phonological features involved in our English results in Figure 4.

**Table 4.** *train, drain, strain*: L2 English [±voice] over L1 Korean [±asp] in onset

Result	Data E1	Data E2	Data E3
Word Data	[–voice, –asp] <i>strainer</i>	[+voice, –asp] <i>drainer</i>	[–voice, +asp] <i>trainer</i>
If L1 [±asp] used	<i>drainer</i> , * <i>trainer</i>	* <i>trainer</i> , <i>strainer</i>	* <i>drainer</i> , * <i>strainer</i>
If L2 [±voice] used	* <i>drainer</i> , <i>trainer</i>	* <i>trainer</i> , * <i>strainer</i>	<i>drainer</i> , * <i>strainer</i>

Notes: Unexpected productions are marked by asterisks (\*).



As shown in Table 4, for the first word *strainer* in Data E1, the production *trainer* is possible only when L2 feature [–voice] is used. If otherwise L1 feature [–asp] is used, then the feature [–asp] would block the production *trainer*. For the second word *drainer* in Data E2, the production *strainer* is impossible when L2 feature [+voice] is used. If otherwise L1 feature [–asp] is used, then the feature would not differentiate *drainer* from *strainer*. For the third word *trainer* in Data E3, the production *strainer* is impossible regardless when L1 [+asp] or L2 [–voice] feature is used. If the L2 feature [–voice] were used, then the production would conform the L2 surface form that would automatically aspirate the initial consonant in the stressed syllable. If otherwise, the L1 feature [+asp] were used, then the perceived form by a native speaker listener would be *trainer*.

In the absence of the acquisition order of phonological features, an alternative analysis of our data may be that the learners produce L2 English /t/ as L1 Korean /t/, and L2 English /d/ as L1 Korean /d/.<sup>11</sup> This analysis calls for more explanation in light of our Korean data, where L2 Korean /t/ and /d/ are not in a one to one correspondence to L1 English /t/ and /d/. Such an analysis must find an independent account for the learnability of the Korean tense consonant /tt/ by L1 English speakers.

## 5.2 L2 Korean features over L1 English features

Table 5 shows that the phonological features involved in our Korean results in Figure 5.

**Table 5.** *tteoyo*, *badatga*, *deureoyo*, *teogiya*: L2 Korean [±asp] over L1 English [±voice] in onset

Result	Data K1	Data K2	Data K3	Data K4
Word Data	[–asp, –voice] <i>tteoyo</i>	[–asp +voice] <i>badatga</i>	[–asp +voice] <i>deureoyo</i>	[+asp, –voice] <i>teogiya</i>
If L1 feature [±voice] used	* <i>deoyo</i> <i>teoyo</i>	* <i>batatga</i> <i>battatga</i>	* <i>teureoyo</i> <i>tteureoyo</i>	* <i>deogiya</i> <i>tteogiya</i>
If L2 feature [±asp] used	<i>deoyo</i> * <i>teoyo</i>	* <i>batatga</i> <i>battatga</i>	<i>teureoyo</i> <i>tteureoyo</i>	* <i>deogiya</i> * <i>tteogiya</i>

As shown in Table 5, for the first word *tteoyo* in Data K1, the production *deoyo* is possible only when L2 feature [–asp] is used. If otherwise L1 feature [–voice] is used, then the feature [–voice] may block the production *deoyo*, but produce *teoyo* instead.

For the second word *bada* in Data K2, the production *badatga* is the only possibility when L1 feature [+voice] is used. If an L2 feature [–asp] were used, then the production would logically be *battatga* with a tense stop [t']. The form *battatga* with a tense stop, however, is not a possibility for many

<sup>11</sup> We appreciate an anonymous reviewer for suggesting this alternative analysis.

learners, as it requires tensing feature. The tensing feature in Korean comprises a constricted glottis, additional subglottal pressure, and tense vocal tract walls.

For the third word *deureoyo*, the production /d/ is the only possibility when L1 feature [+voice] is used as in the context *norae deureoyo* 'I'm listening to songs.' If otherwise an L2 feature [-asp] were used, then the production would perceptually be both voiced and voiceless versions, *deureoyo* and *teureoyo*. The tensed form *tteureoyo* for this word is not a possibility, as it requires the tensing feature.

For the fourth word *teogiya* in Data K4, the production /d/ is impossible regardless when L1 [-voice] or L2 [+asp] feature is used. If the L2 feature [+asp] were used, then the production would conform the L2 surface form that would automatically devoice the given consonant. If otherwise, L1 feature [-voice] is used, then the perceptual form would be *teogiya* in the absence of tensing.

## 6. Conclusion

Our results on the relationship between L2 production and phonological features have shown that learners' acquisition order is irrelevant to phonological status of features as to whether the feature is contrastive in the target language or in the native language. The crucial evidence comes from the incorrectly perceived pronunciation *trainer* for the English word *strainer*; and the incorrectly perceived pronunciations *deoyo* and *teoyo* for the Korean word *tteoyo*.

If the learners were to use phonological features at all for acquiring a foreign language, then the use of features would have to be all inconsistent. Firstly, L2 English learners would have used the L2 feature [-voice] rather than L1 feature [-asp] to incorrectly produce *trainer* for the word *strainer*. Secondly, the L2 Korean learners would have used L2 feature [-asp] before instruction to incorrectly produce *deoyo* for the word *tteoyo* and L1 feature [-voice] after instruction to produce *teoyo* for the word *tteoyo*. Thirdly, they would have used neither L1 feature [-voice], nor L2 feature [+asp], when they incorrectly produced *deogiya* for the word *teogiya*. The results therefore confirm and support the previous findings by Flege and Port (1981), but do not support the views by Han (2009) and Hanchin-Bhatt and Bhatt (1997).

Our results were obtained from the Korean and English languages by recording the homogeneous group of L2 speakers from the same L1 that are rated by native speaker listeners. While Han (2009) employed a perceptual experiment on Korean non-sense words produced by Japanese learners, we newly conducted the production experiment and on the learners and listeners of native English and Korean speakers. The disagreement in literature arises in part from the fact that an L2 speech production study involves a time-consuming task dealing with tremendous variation. A speech

production study usually involves series of tasks: recording, processing, acoustic measurement, perceptual evaluation, and statistical analysis. A study on non-native speech data involves far more variation than native speech forms due to varied level of proficiency and difference in native language backgrounds. This lack of consistency is due to the fact that the learner speech is the transitional form between the L1 form and the closer approximation to the target speech form of L2. Furthermore, a study on speech production must deal with more variation than other areas of linguistic studies, due to the fact that each speech realization is not the same for a speaker, let alone different speakers.

We resolve these variation problems by implementing a new method for this study: fixed set of native and target languages, reciprocal phonological features of contrastive and complementary distribution, and focusing on (near) minimal pairs of words. We fixed the native and target languages to Korean and English, which belong to different language families. We selected the reciprocal phonological features of aspiration and voicing that are contrastive in one language and complementary in the other. We focused on comparative data in each language: *this strainer, this trainer, this drainer* in English, *deoyo, teoyo, tteoyo* in Korean.

#### Appendix A. Recording list for Korean learners of English

The list included the three testing sentences that are mixed with 49 fillers. The testing sentences are in No. 3, 8, and 10.

1. Let me get an apple.
2. It's a passion magazine.
3. I like to use this trainer.
4. Are you planning to live here?
5. He has a bad cough.
6. Let me get a ticket.
7. He found the buck.
8. I like to use this strainer.
9. John rested after the thief got arrested.
10. I like to use this drainer.
11. It is a real door.
12. He found the book.
13. I'm waiting in line for Bret.
14. Two of your tires look worn.
15. It's a fashion magazine.
16. He has a bad cuff.
17. You look good in that collar.
18. Let me get an appeal.
19. Did you find the rake?

20. She took the lid.
21. I don't like to walk there.
22. I like the time.
23. I don't like to work there.
24. He surface on the surfs of the waves.
25. We need ten right hats.
26. The ghost enjoys horror and night.
27. The sport fans enthusiastically support the team.
28. We counted all lights.
29. You look good in that color.
30. Let me get an ad bill.
31. He surfs on the surface of the waves.
32. That's what I set.
33. Let me get a tea kit.
34. Did you find the lake?
35. We counted all nights.
36. The ghost enjoys horror at night.
37. I like the chime.
38. That's what I said.
39. The support fans enthusiastically sport the team.
40. We need ten light hats.
41. John arrested after the thief got rested.
42. She took the lead.
43. I'm waiting in line for Brad.
44. I'm waiting in line for bread.
45. We need ten night hats.
46. It is a rear door.
47. Are you planning to leave here?
48. If the birthday party wasn't for Mary, then who was it for?
49. Jane saw a picture of the boy she was fond of.
50. John went to visit the woman he had written to.
51. I can run faster than you can.
52. He was invited to a costume party as a guest, but what did he dress as?

### Appendix B. Recording list for Korean learners of English

The recording list included the four testing sentences that were mixed in the list of 108 sentences in the book by Choo and O'Grady (2003).<sup>12</sup> The remaining 104 questions served as fillers. The 108 sentences were taken from the first two comprehension exercise items of the book. The sentences were listed by the same order as in the book, and the learners would not know which items actually be used in this experiment. We present below the parts of the recording list that include the testing sentences in No. 7, 11, 32 and 83. The numbers represent the order that they were presented among 108 sentences.

No.	Examples	Romanization
6	풀이 뾰족해요. Herb is sharp.	ppuli ppyojokaeyo.
7	누구 턱이야? Treat to whom is that?	nugu teokiya.
8	금이 두 톤이에요. The gold is two ton.	geumi du toniyeo.
10	그 친구 또 왔어? Did that friend again to come?	geu chingu tto wasseo?
11	물에 떠요. It floats on water.	mure tteoyo.
12	손이 떠요. My hands are getting floated.	soni tteo yo.
31	잠깐 들리요. Stop by for a moment.	jamkkan deulleoyo.
32	노래 들어요. I'm listening to songs.	norae deureoyo.
33	극이 싱거워요. Pole is not salty enough.	geuki singgeoweoyo.
82	열 병을 마셨어요. I drank ten bottles.	yeolppyeongeul maseosseoyo.
83	바닷가에 가요. We are going to the beach.	badatgae gayo.
84	바닷물은 짜죠. Sea water is salty, of course.	badanmul-eun jjajo.

<sup>12</sup> Of these, a different set of 25 question items was used in the author's own work on a different research topic (Kim 2012). The rating data used in the current paper were newly acquired, because the purpose, subjects, methods, and procedure for rating analysis were different from the previous paper. There were a total of 104 question items, as mentioned in the previous paper, that were made of these 108 sentences from the book by Choo and O'Grady (2003).

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received: March 10, 2015  
revised: April 18, 2015  
accepted: April 22, 2015