Acoustic variation in Korean vowels spoken by beginning and advanced native English learners of Korean*

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Kang, Seokhan & Ahn, Hyunkee. 2011. Acoustic variation in Korean vowels spoken by beginning and advanced native English learners of Korean. *The Linguistic Association of Korea Journal.* 19(3). 47-65. An analysis showing the effect of L2 exposure on the acoustic patterns of vowel variation was presented for native English learners of Korean with differing levels of proficiency. Speech materials consisted of seven Korean vowels in isolated framed sentences. The analysis was based on measurements of duration and the frequencies of the first two formants from the vowel tokens. Recordings were made for ten BEK (beginning native English learners of Korean) and ten AEK (advanced native English learners of Korean) who were living in Korea at the time of the experiment, along with ten native Korean speakers as control group. These 30 speakers were all males in between 25 to 35 years of age. Differences among the three groups were found in the acoustic features of vowels. The advanced native English learners of Korean group exhibited shorter duration and closer values of F1 and F2 of the vowel to the native Korean group, providing evidence of more accurate articulatory position. In comparison between the two native English groups, it was safe to say that the effect of proficiency had some influence on formants and duration of L2 vowels. Each vowel, however, was found to be slightly different in its degree of proficiency.

Key Words: vowels, Korean, English, formant, duration, SLA, exposure, background language, bilingual transfer

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1. Introduction

This paper describes variations in Korean vowels spoken by two proficiency levels of native English learners of Korean and a native Korean speaking group (control group), examining variation in the patterns of acoustic characteristics of the 7 vowels in Korean (/i, e, ɨ, ʌ, a, u, o/). The reasons for describing these variation patterns are twofold. Firstly, in recent years it has become gradually accepted that a language's vowel system is better characterized in L2 acquisition when its description includes developmental patterns in a homogeneous group (e.g., Adank, van Hout & Smits, 2004; Aoyama & Guion, 2007). Secondly, many variations between L2 learners and native speakers' performance provide evidence of L1 interference/transfer to L2. Thus, this study has focused on the effect of exposure between two groups of native English learners of Korean along with a native Korean-speaking group as control group. The present study investigates production of segment-level temporal and spectral features by native and non-native speakers of Korean. The overarching goal of this research is to analyze the systematic acoustic/phonetic features of L2 learners' pronounced vowels and to relate these features to native-like intelligibility.

Intelligibility refers to the comprehension of messages in the sense intended by the speaker (Jenkins, 2000; Nelson, 1982). Even though L2 intelligibility is closely tied with both segmental (Jenkins, 2000; Munro & Derwing, 2008) and suprasegmental factors (Anderson-Hsieh & Koehler, 1992; Tajima, Port & Dalby, 1997), some research has reported that segmental factors were more important than suprasegmental features for perceived foreign accent and intelligibility (Guion, Flege, & Loftin, 2000).

This study measures duration and the first two vowel formants as segmental features. Duration is always an available cue in representing the physical signal of speech, and could be exploited as a vowel feature (Kent & Read, 2003). There are substantial differences in the extent to which these temporal features are realized cross-linguistically, which presents a meaningful opportunity for investigating foreign-accented speech. Aoyama and Guion (2007) investigated some acoustic aspects of English native and Japanese non-native speech in American English. In this study, they reported that absolute durations of syllables and utterance tended to be longer in the native Japanese ESL speakers'

utterance than those of the native English speakers. This study implies that L2 speakers tend to produce a longer duration of segments. The first two formants have also been measured because traditionally they produce articulatory features of the vowels very clearly. Some research reported that these features were expressed differently by some variables in the process of second language acquisition. Mitsuya et al., (2010) reported that the effect of background language had different influences on formant frequencies. Three groups of subjects (Native English, Japanese ESL, and Korean ESL) produced tokens of the English word "head" with the first formant (F1) shifted either up or down in frequency. When F1 was shifted up, compensations by native English speakers were larger (around 50Hz) than either ESL group (Japanese 20 Hz and Korean 5 Hz). For example, F2 of Korean subjects was shifted downward with a 5 Hz in the F1-up condition, while in the F1-down condition, the F2 was shifted upward by the same increment.

Relatively little study has been carried out on the features of the Korean vowels for English-speaking learners of different levels who have learned Korean, and also on the comparison of Korean vowels spoken by both native English groups and Korean speakers. This paper attempts to provide an authentic overview of the extent to which Korean vowels vary in their acoustic characteristics across various levels of proficiency. In doing so, this research could serve as a point of reference for further studies on the developmental patterns of KFL/KSL (Korean as a Foreign or Second language) for native English learners of Korean.

2. Materials

2.1 Subjects

Twenty English-speaking males who have learned Korean in Seoul and ten male Korean native speakers also from Seoul participated in this study. The English members were classified into two groups according to their levels of Korean speaking proficiency: beginning native English learners of Korean from north America (hereafter, BEK) who have studied Korean in beginning classes

(with a learning period ranging from 2 months to 12 months) and advanced native English learners of Korean from north America (hereafter, AEK) in advanced classes (with a period of learning time between 24 and 36 months). Most subjects of BEK were enrolled in the first or second level of a Korean course, while members of AEK were enrolled in level four or five (intermediate or advanced courses of Korean).

The English-speaking subjects were visiting students or regular graduate students at a university in Seoul, Korea. Eleven out of twenty were from the United States, and nine were from Canada. All the Korean subjects were undergraduate students at the same university, in Seoul, Korea. None of the subjects reported any history of speech or hearing impairments.

Table 1. Subjects' information

	Proficiency level	Mean Korean study duration (year)	Mean age (year)
Native English learners of Korean	Beginning	0.6	28.2
	Advanced	2.7	30.1
Native Korean speakers	-	-	22.3

2.2. Recording procedure

The Korean monophthongal vowels[1] /i, e, ɨ, ʌ, a, u, o/ in mono-syllabic words were used as test words. The test words were embedded in a carrier sentence: *i kəsɨn ___ ta*, "This is _____". Following is the spectrogram spoken by one subject.

1) The amount of monophthongal constituents of the Korean vowel inventory has been the subject of debate by Korean linguists. It has been suggested that six to ten vowels exists: 10 vowels (Her W., 1965), 9 vowels (Oh J-R, 1993), 7 or 6 vowels (Sin J-Y, 2001; Cho S-M, 2003). This study employed a 7 vowel system by following Kwak C-K(2003).

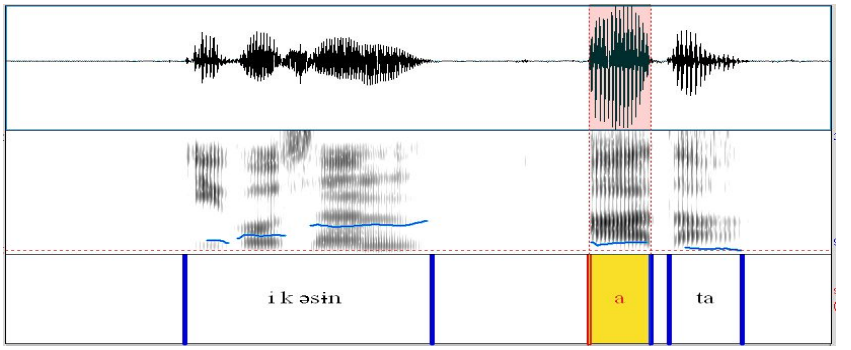


Figure 1. Waveform and Spectrogram of one sentence including target vowel of /ㅇㅏ/[a] produced by a member of North American English learners of Korean.

Both English-speaking subjects and Korean-speaking subjects read the same Korean sentences. Sentences were given in the Korean orthography for all subjects. Test sentences were randomized for each subject. Each test sentence had two repetitions and this study employed all productions. Thus, the total numbers of test vowels[2] were 420 (30 subjects x 7 vowels x 2 rounds).

2.3 Recording

Each participant was asked to read each English sentence twice. Before they produced the sentences, the ability of the subjects to understand the meaning and pronunciation of the sentences was confirmed. In this experiment, however, two beginning levels of subjects of native English speakers out of 10 were given 10 to 30 minutes to practice the sentences before recording because they had somewhat difficulty in reading experimental scripts fluently. Their particular reading style might have some effect on the experiment and would be discussed in section 4.2.

Audio was recorded in a professional phonetics laboratory with a SONY DAT recorder (TASCAM DA 20AMK II) using a Shure SM 10A microphone,

2) Ordinally we tested 10 vowel system (/i, e, ɛ, ɨ, ʌ, a, u, o, wi, wa/). We removed two diphthong sounds in the analysis because our experiment focused on monophthong vowels showing the steady-state features. Also the sound of /ɛ/ was ignored because both /e/ and /ɛ/ showed similar values in measured cues for all three groups and these two sounds were immerged into one in Seoul Korean (Kwak C-K, 2003).

digitalized at 44.05 KHz and 16 bit resolution.

2.4. Measurement

Experimental sentences containing the target vowels were used to evaluate the Korean vowels produced by each group. Acoustic measurements for vowel duration (ms) and the first two formants (Hz) were made. Duration and formants were measured using a waveform display with a time-locked wideband spectrogram through the use of PRAAT (5.1.17). The vowel duration was measured from the initial acoustic signal of F0 in the spectrogram to the final acoustic cue of F0 at the boundary (Kent and Read, 2003; Ladefoged, 2003). We checked the cues of the F0 as the primary cue and second formant movement as the supplementary cue. The start and end times for the duration of each token were labeled manually in the digitized speech wave. Labels were placed at zero crossings at the onset and offset of the glottal vibrations in the vocalic portion of the vowel(See Figure 2). The duration of each vowel segment was defined as the interval between the segment labels at the start and end of the vocalic portion.

The frequencies of F1 and F2 were measured at the mid (fifth) point of the vowel token's duration, based on a nine-point division of the vocalic portion into eight equal intervals, with the first point at the start and the ninth point at the end of the vowel by following the report of Adank et al. (2004) that these vowels can be separated fairly well based in this point on their steady-state characteristics for their first two formants. For further specifics of the acoustic measurements, see Kent & Read (2003) and Adank, van Hout, and Smits (2004).

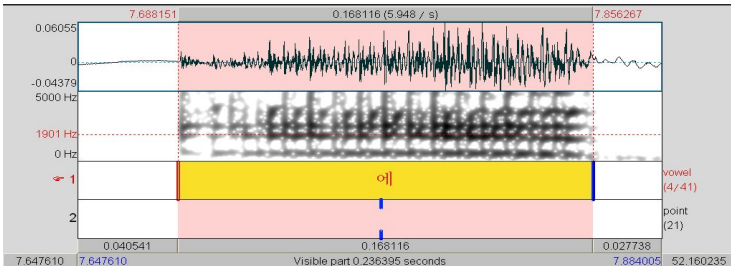


Figure 2. Waveform and Spectrogram of /에/[e] produced by a member of North American English learners of Korean.

2.4.1. Duration

In total, 420 Korean items produced by subjects were employed for acoustic analysis. All measurements were taken by hand with PRAAT. For precise boundary locations and measurements, waveform and spectrogram data were considered together. Vowels were identified by the presence of vocalic movement. The duration of vowels was measured from the beginning of vocalic movement to the zero-crossing of the end of the movement preceding the onset of pause before 'ta', the Korean verbal ending mark. Figure 2 shows an example of segmentation for the purpose of measuring vowel duration.

2.4.2 Formant Frequency

Vowel quality could be quantified with adequate precision and validity by measuring the first two formants. Specifically F1 corresponded closely to the articulatory dimension of vowel height, while F2 reflected the place of maximal constriction related with vowel front/back position (Stevens, 1998). The first two formants of vowels /i, e, ɨ, ʌ, a, u, o/ were measured at fifth point - at 50% of the entire vowel duration (see Figure 2).

3. Results

3.1. Duration

It was found that length of vowel duration was inversely proportionate to the length of Korean language exposure time. For the mean value of the vowel duration, BEK (beginning native English learners of Korean) produced an average length of 174.06 ms and AEK (advanced native English learners of Korean) returned a result of 150.00 ms, while native Korean speakers showed the shortest duration of 138.30 ms. Table 2 expresses the average duration measurements for all vowels across the three groups.

Table 2. Mean value of vowel durations (ms) spoken by three groups.

	BEK	AEK	Korean
1. [i](이)	167	130	126
2. [e](에)	151	152	143
3. [ɨ](으)	163	161	141
4. [ʌ](어)	198	171	148
5. [a](아)	212	147	139
6. [u](우)	158	146	137
7. [o](오)	170	147	132
Mean	174.06	150.00	138.30

One-way ANOVA was performed on the duration measurements for each vowel token, with three groups as an independent factor. The analysis showed a significant main effect of vowel duration with groups ($F[2, 419]=18.421$, $p<.0001$). Tukey post-hoc analysis ($p<0.001$) for groups showed that the vowel duration of advanced Korean learners was more similar to that of the native Korean group, in that the advanced group produced overall shorter vowel duration than the beginning group. The vowels of Korean native speakers were generally the shortest of all groups.

Overall, a longer exposure to the Korean language caused a shortened duration in vowel pronunciation for American-English learners of Korean. Clearly a better proficiency in Korean improved the speed of vowel pronunciation in which AEK's duration was shortened almost 25 ms shorter than BEK's. Considering that vowel duration is closely tied with speech rate as a suprasegmental variable, this feature could be interpreted as a decision factor of L2 proficiency. According to Munro and Derwing (2008), L2 beginners exerted slow speech rates compared with advanced L2 learners and native L1 speakers because L2 speech rates could be influenced by difficulty in interpreting L2 phonemes, articulatory problems, and psychological factors. Along with this study, Kang and Rhee (2011) reported that evaluation on L2 speech rate showed different criteria on L2 proficiency by following the effect of background language. Native English raters evaluated strictly on speech rate, including a larger difference on speech rate between good and bad grade, while

Korean English raters' evaluation showed a comparatively flexible criterion: smaller difference on speech rate between good and bad grade.

However, some vowels such as non-low vowels of [e] and [ɨ] remained relatively unchanged as shown in Table 2. The difference between BEK and AEK in these vowels was just within 3 ms. On the contrary, [a] with both non-high and non-front features showed the dramatic change over the degree of L2 proficiency. The durational change of [a] between BEK and AEK was around 65 ms. The result implies that, in addition to L2 proficiency articulatory problem, L2 phoneme information has some influence on durational change.

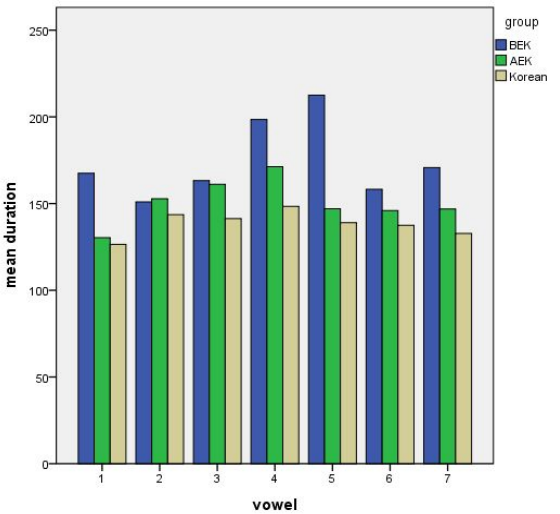
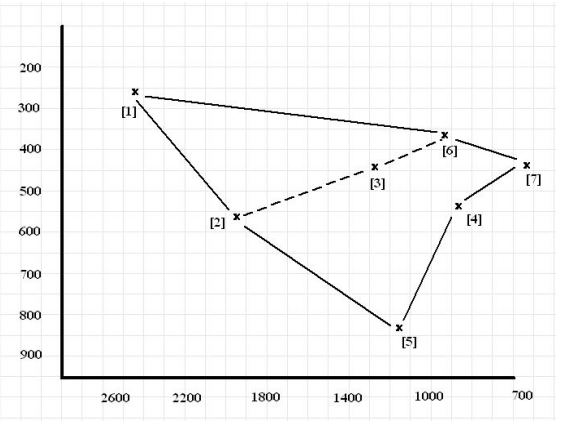


Figure 3. Mean duration (ms) for BEK, AEK, and Koreans. 1:i (이), 2:e (에), 3:ɨ (으), 4:ʌ (어), 5:a (아), 6:u (우), 7:o (오).

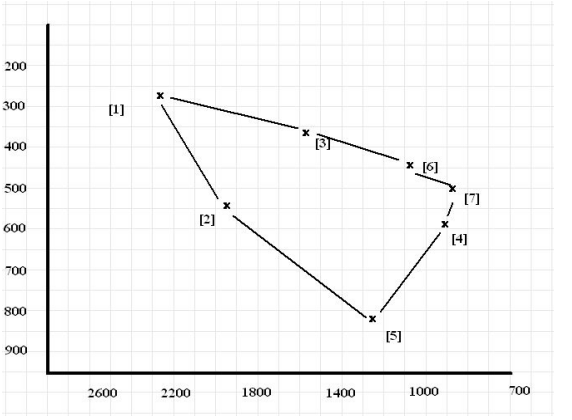
3.2. Formant frequencies

The formants of seven monosyllabic vowels, /i, e, ɨ, ʌ, a, u, o/, were measured at 50% of each vowel token's duration. Statistical ANOVAs were run on the pooled measurements of F1 and F2 for each vowel token. The analysis showed that F1 performed a statistically meaningless effect with groups ($F[2, 599]=1.010$, $p>0.05$), while F2 performed a significant main effect with groups ($F[2, 599]=12.536$, $p<0.0001$. A post-hoc analysis of F2 ($p<0.001$) for groups

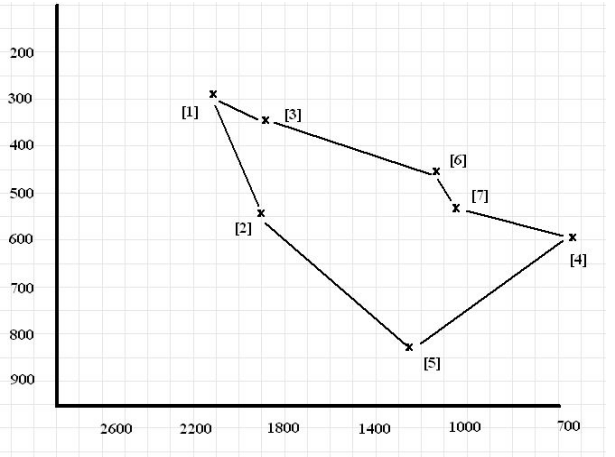
exhibited that three groups were categorized into two: BEK and AEK, and AEK and Koreans. The results exhibited that BEK produced lower frequency (1422 Hz) than both AEK (1592 Hz) and Koreans (1777 Hz). This means that articulatory position could be changeable over the L2 proficiency in learning Korean, while articulatory height (expressed as F1) shows less variation. The following diagrams show average formant frequencies for all vowels.



(a) Beginning American–English learners of Korean



(b) Advanced American–English learners of Korean



(c) Native Korean speakers

Figure 4. Vowel diagram showing average formant frequencies (Hz) for all vowels: (a) Beginning American–English learners of Korean, (b) Advanced American–English learners of Korean, (c) native Korean speakers. 1:i (이), 2:e (에), 3:ɨ (으), 4:ʌ (어), 5:a (아), 6:u (우), 7:o (오).

These figures demonstrate the average values of the first two formants for three groups. The meaningful observation over L2 vowel change puts on the articulatory size. The articulatory size of advanced English learners of Korean approaches to that of native Korean speakers; that is, they have smaller articulatory size than that of beginning English learners of Korean. Note that articulatory size in producing English vowels is larger and wider than in producing Korean vowels (See Kent & Read, 2003). Another interesting symptom on L2 vowel change occurs on the vowel of [ɨ]: rasing and fronting. AEK's articulatory movement on [ɨ] shows the tendency to approach to native Koreans' articulatory system. The result supports the idea that the effect of L2 proficiency caused meaningful change in L2 articulatory size and system.

Table 3. Mean value of the first two formants (Hz) of Korean vowels produced by BEK and AEK.

		BEK	AEK	Korean
1.[i](ㅇㅣ)	F1	283	279	270
	F2	2314	2275	2117
2.[e](ㅇㅔ)	F1	530	532	551
	F2	1893	1908	1819
3.[ɨ](ㅡ)	F1	427	378	356
	F2	1219	1621	1898
4.[ʌ](ㅓ)	F1	527	606	616
	F2	935	909	944
5.[a](ㅇㅏ)	F1	826	826	837
	F2	1178	1298	1311
6.[u](ㅜ)	F1	378	454	470
	F2	982	1050	1108
7.[o](ㅗ)	F1	479	474	507
	F2	742	856	914

Even though a little variation between two Korean-learning English groups could be found in few vowels, the effect of L2 proficiency clearly has some influence on acoustic variation of duration and the first two formants in most of vowels. The result suggests that the more they are exposed (or proficient) in the L1 environment, the closer they are able to produce vowels similar to that of native speakers.

4. Discussion

4.1. Vowel variation

4.1.1. Duration

Considerable group differences were found in the acoustic features of Korean vowels. The duration of the vowels for Korean native speakers was overall shorter than for two English groups with differing level of Korean proficiency. Koreans produced vowels with 77% of the duration of BEK (beginning American-English learners of Korean), and 85% of AEK (advanced American-English learners of Korean). Within groups, Koreans pronounced back-vowels comparatively fast, while BEK produced front-vowels relatively fast. AEK showed similar patterns

with native Korean speakers in durational production.

Concerning the effect of L2 proficiency, the vowel durations for AEK were shorter than BEK. They showed a common slow speed in producing unique Korean monosyllabic vowels of /a/ and /i/ in that the duration of these two vowels was comparatively longer by 20% to 30%, compared with other vowels.

Differences were found more frequently between two groups. Especially, the non-front vowels were significantly different. BEK produced non-front vowels of /ɨ, ʌ, a/ with a comparatively longer duration, while AEKs' longer production puts on the vowels of /e, ɨ, ʌ/. It is interesting that the duration of the vowel /e/ was the least changeable of all groups.

More interestingly, among the three groups, variation was distributed differently; that is, duration of vowels spoken by Koreans showed comparatively little variation over vowels (126 ms to 148 ms). On the contrary, BEK showed the largest range from 151 ms to 212 ms and AEK placed in the mid position (147 ms to 171 ms). The results suggested that L2 proficiency was proportionate to the durational variation among L2 vowels.

4.1.2. F1 and F2

The analysis for the steady-state measurements for the seven monosyllabic vowels exerted meaningful group differences. We can find statistical group differences over F2 of Korean vowels, not over F1. It seems that F2 is more vulnerable to change than F1. That is, the monosyllabic vowels of the experimental groups varied mostly in their tongue position, and less in their tongue height, especially for English groups.

In the specific vowel analysis, F1 was influenced comparatively much (due to the effect of proficiency) on the 4 non-back vowels /i, ɨ, ʌ, a/ and F2 was influenced for 5 vowels of /i, e, ɨ, ʌ, u/. The analysis supported the hypothesis that F2 could change more easily. Interestingly, the mid-back vowel /o/ showed a significant change in formant values over the three groups. It is possible to say that Korean /오/ and English /o/ have similar acoustic features at the 50% duration point.

4.2. The effect of L2 proficiency

The results of these analyses indicated that there was sufficient vowel

variation as demonstrated in the measurements of the vowel duration and the first two formant frequencies for two homogeneous groups. L2 proficiency was a somewhat clear indicator of vowel variation. In the experiment, the absolute duration of vowels tended to be shorter for the advanced native English learners of Korean. Also acoustic composition of F1 and F2 for the advanced native English learners of Korean approached that of native Korean pronunciation[3].

In spite of the significant effect of L2 proficiency, experimental style might be another considerable factor. The difference between the two English groups that might result from experimental style is due to the need for a clear production. Some beginning English learners (2 out of 10) of Korean lacking knowledge of the Korean alphabet produced comparatively clear pronunciation. This experimental style might cause some variation in the acoustic features due to the careful reading by the members of the group. It is well documented (Chambers, 2003; Labov, 1972) that speakers tended to use clearer utterances in the laboratory speaking. In more formal speaking styles, the beginning L2 learners tended to use clearer utterances (i.e., slower production) than the advanced subjects. The recording method, in which the recording was conducted in a relatively formal setting and where the vowels were pronounced in the sound-proof laboratory, may have had an influence on vowel articulation. When reading sentences aloud, native English learners of Korean were generally over conscious of their speaking style and tended to carefully monitor their pronunciation. The formal setting in relation to the project here might have induced them to be careful about their pronunciation.

However, the results indicated that group difference might well be presented entirely in acoustic features, even though the speech was recorded in a formal setting. Considering that both English groups taking part in the recording produced careful pronunciation, it cannot be denied that the effect of proficiency had a significant influence on vowel articulation and duration. The study of Trofimovich and Baker (2006) on Korean English learners draw the result that the effect of experience improved the duration as well as some other acoustic cues, even though this study was conducted in the formal setting.

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3) A reviewer points out the possibility of cavity difference among groups, commenting our result that the effect of L2 proficiency evokes the formant change. On the relationship between formant structure and cavity size, please see the study of Kang S-H(2008).

It would therefore be interesting to compare the present results with acoustic measurements of vowels recorded in one of the more informal tasks related to personal production. This may lead to even more extensive group variation patterns to be uncovered between these groups.

4.3. Influence of the background language

The variation presented here in vowel durations and formant frequencies was considerably influenced by the background language. The reason for this is simple; that is, the different structure of vowels between the two languages involved in shaping L2 articulatory position.

English has monophthongal vowels of /iː, ɪ, ɛ, æ, aː, ɔː, ʊ, uː, ʌ, ɜː/, while Korean has fewer vowels of /i, e, ɨ, ʌ, a, u, o./. Even though the two languages have similar vowel structure, the pattern is dramatically different. The English vowels can be divided into two major phonological groups: tense (long) versus lax (short) vowels. Thus, the vowel duration in English plays an crucial role in contrasting the pairs, while Korean does not use length as a vowel feature at the phonological level. From this result we expect that English native speakers would be more sensitive to durational change in their response.

Another difference comes from the difference of formant frequencies inherited in the background language. The following table shows the formant structure for some vowels between two languages produced by native speakers speaking their native language.

Table 4. Mean value of the first two formants (Hz) of English spoken by native English speakers and Korean spoken by native Korean speakers.

		i	e	ɛ	ʌ	o	u
English*	F1	300	497	694	638	523	353
	F2	2345	1982	1622	1455	1128	1067
Korean**	F1	341	526	542	593	456	374
	F2	2281	1948	1950	1263	857	1045

*Assmann and Katz (2000)

**Cho S-M(2003)[4].

4) Kwak C-K (2003) reported that in Seoul dialect of Korean both sounds of /e/ and /ɛ/ were

Different acoustic features may be involved in improving the correct articulatory position for native English learners of Korean. However, the effect of background language has some selective influence on vowel formants; that is, less impact on [a] and [u] which do not appear in front position, and larger impact on [i], [e], and [ʌ], which are frequent in non-back position.

5. Conclusion

It seems justified to conclude that the acoustic differences of Korean vowels produced by two groups of native English learners of Korean with different levels of Korean proficiency are, to a large extent, found in duration and formant frequencies. This suggests that the high level of proficiency for L2 learners may guarantee the improvement of precise vowel articulation in producing Korean speaking.

However, an exception may exist to this generalization. Both English groups had difficulty in producing the non-front vowels of [a] and [u]. The difference between both English groups was found in the acoustic features. Beginning native English learners of Korean produced with longer durations as in [a], while advanced native English learners of Korean produced [ʌ] with the longest duration. It means that the articulatory improvement could be vowel-specific. In all three groups, including Korean native speakers, the shortest duration was seen in the front-unround vowel [i].

In summary, the advanced native English learners of Korean group was found to have more native-like pronunciation of vowels than the beginning group. However, some formant-related vowels tended to be resistant to change in spite of immersion in Korean. Future research is needed to determine whether these characteristics contribute to the diminished intelligibility or to the detection of foreign pronunciation through perception tests.

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immerged into one. On the contrary, Cho S-M(2003) investigated formants of these sounds separately.

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