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ABSTRACT

This study examined the quality of three English vowels and their Korean counterpart vowels by measuring F1/F2 frequencies and investigating how the different vowel qualities influenced consonant voicing. Participants were six native speakers (NS) of English and six NS of Korean who were graduate students at a large U.S. university. F1/F2 frequencies of vowels produced by the subjects were measured on spectrograms in a speech analyzer, and the accuracy of their vowels and final stops was determined by four English NS raters. The study did not conclusively show what effect different vowel qualities had on consonant voicing, because most of the Korean subjects failed to pronounce voiced stops accurately. However, F1/F2 frequencies of English vowels produced by Korean NSs were superimposed between native English and Korean vowels. This indicates that when Korean speakers produce English, they assimilate native English sounds. The Korean /a/ was much higher than the English /a/. The Korean and English /i/ were similar. The F1/F2 frequencies of Korean males' English vowels were different from their Korean counterparts and shifting toward native English. (Contains 28 references and 4 figures.) (SM)

Vowel Quality and Consonant Voicing: The Production of English Vowels and Final Stops by Korean Speakers of English

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Due to the fact that the Korean language does not allow voiced obstruents, it is presumable that Korean speakers of English may have difficulties when they produce voiced obstruents of English. With respect to the accurate production of voiced obstruents, there are studies that claim that the quality of the vowel influences nonnative speakers' (NNSs') accuracy of voiced stops (e.g., Yavas, 1994). In this respect, the present study examined the quality of three English vowels, /i/, /ʌ/, and /a/ and their Korean counterpart vowels by measuring F1/F2 frequencies and investigating how the different vowel qualities influenced consonant voicing. Six English and six Korean native speakers (NS) participated. F1/F2 frequencies of vowels produced by the subjects were measured on spectrograms in a speech analyzer, and the accuracy of their vowels and final stops was determined by four English NS raters. It is difficult to tell from the study what effect different vowel qualities have on consonant voicing because most of the Korean subjects failed to pronounce voiced stops accurately. A noteworthy phenomenon was that F1/F2 frequencies of English vowels produced by Korean NSs were superimposed between native English and Korean vowels. This indicates that when Korean speakers produce English they assimilate native English sounds. As such, it is predictable that F1/F2 frequencies of more advanced L2 learners (i.e., somewhat successful with voicing) may be similar to those of native English speakers.

INTRODUCTION

While English has voiced sonorants and voiced and voiceless obstruents, Korean only has voiced sonorants and voiceless obstruents. As a result, one may expect Korean speakers who are learning English to have difficulties when they produce voiced obstruents in English. This expectation may not, however, be accurate because of pre-, post-, and intervocalic voicing rules that indicate that vowels (or vowel quality) can influence consonant voicing (Anderson & Stageberg, 1975; Locke, 1983; Yavas, 1994). Major and Faudree's (1996) study showed that because Korean has the intervocalic rule, Korean speakers do not have difficulty with voiced stops in medial position. Based on the literature, the present study: (a) examines the quality of three English vowels, /i/, /ʌ/, and /a/ and their Korean counterpart-vowels by measuring the first and second formant (F1/F2) frequencies, and (b) investigates how different vowel qualities influence final stop voicing (in this study only stops in the final position are analyzed).

The reason why the vowels /i/, /ʌ/, and /a/ were chosen for this study is that the seven vowels (i, e, ɛ, ʌ, a, o, u) are typically transcribed with the same

International Phonetic Alphabet (IPA) symbols in English and Korean (Yang 1996), and of the seven /i/, /ʌ/, and /a/ reveal the most representative positions of the tongue within the oral cavity as the high-front, low middle-center, and low-back positions respectively. Because these three vowels cover any possible position of the tongue within the oral cavity, it is possible to extract a general perception on the relationship between vowel quality and consonant voicing by looking at how they affect the voicing of consonants.

The quality of /i/, /ʌ/, and /a/ produced by native English and native Korean speakers was estimated from formant frequency measurements since formant frequency provides a convenient way of representing a given vowel system and of depicting differences in vowel systems between languages or dialects (Rosner & Pickering, 1994). For the purpose of this study, only the first and second formant frequencies were considered. In articulatory terms, F1 is related to tongue height while F2 is related to tongue advancement. Front vowels such as /i/ have a low F1 and a high F2. In contrast, back vowels such as /a/ have a high F1 and a low F2.

The technique used to measure the relation between English and Korean vowels is to plot their F1/F2 formant frequencies on a spectrogram. In doing so, there are some potential problems. That is to say, uncontrolled phonetic contexts may create remarkable lags between the values of F1/F2 frequency (Flege, Bohn, & Jang, 1997). Bearing this in mind, this study was designed in a controlled context. The Korean and English words selected for this study were monosyllabic with stressed vowels (/i/, /ʌ/, and /a/), coda (voiced and voiceless stops), and consonant vowel consonant structure (see Appendix).

Research Questions and Hypotheses

Most Korean speakers learning English, especially learners in the initial stages, assume that Korean vowel quality is identical to English vowel quality in counterpart pairs for two reasons: a) because of symbol-based first language (L1) and second language (L2) comparisons provided by phoneticians, and b) non-native vowel perceptions that result from learners perceiving L2 vowels with phonological contrasts in L1 (Flege, 1992; Ingram & Park,1997). This is evident when looking at how English phonetic alphabets are taught in institutional settings (e.g., family, schools) in Korea. However, as far as the literature is concerned, research shows that all languages have some variations in vowel quality due to differences in the vowel height (e.g., Ladefoged & Maddieson, 1990; Yavas, 1994), and that the assumption that counterpart vowel pairs in English and Korean are identical should be challenged. In this respect, the present study was designed to verify Korean vowel quality in relation to English vowel quality asking specific questions: (a) is Korean vowel quality really the same as English vowel quality? and (b) if identical vowels reveal different qualities in articulatory tests, what happens when Korean speakers of English use Korean vowel sounds in English words? Stated another way, if Korean NSs

use Korean vowel quality in English words, how does it affect the production of final stops? Does it enhance or decline the accuracy of final stops?

Prior to this study, the researcher expected to find certain phenomena in the F1/ F2 frequencies of /i/, /ʌ/, and /a/ in three different groups (Koreans speaking Korean, Koreans speaking English, and Native English speakers speaking English). The researcher's expectations were: (a) the F1/F2 frequency of each vowel in the groups would differ, and (b) because of the different vowel qualities between English and Korean, in the case of Korean NSs, the relationship between vowel quality and consonant voicing would show different results from earlier studies conducted with native English speakers or other language speakers (e.g., Japanese).

Vowel Articulation and Quality: English and Korean

Each vowel has a characteristic vocal tract shape that is determined by the position of the tongue, jaw, and lips. Because the jaw and tongue usually work together to increase or reduce the mouth opening, vowel production is often described by specifying the position of two articulators: the tongue and the lips.

According to lip articulations, vowels are classified as being either rounded or unrounded. Vowels are classified by the articulatory position of the tongue in regard to height, front-back (backness), and roundness (Bernthal & Bankson, 1988; Ladefoged & Maddieson, 1990; Pennington, 1996). Twelve monophthong vowels (i, ɪ, e, ɛ, æ, ə, ʌ, a, ɔ, o, U, u) in American English are identified by these features of articulation within the oral cavity. Of these twelve, five vowels (i, ɪ, e, ɛ, æ) are formed in the front of the mouth. The vowels /u/, /U/, /o/ and /ɔ/ are articulated in the back of the mouth with the back of the tongue raised. The central vowels include /ə/, /ʌ/, and /a/. Together, these twelve vowel phonemes of English are diagramed in Figure 1 below.

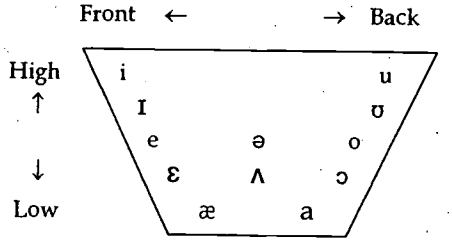

Figure 1. Position of English vowels in the vocal tract

In a similar manner, the phonetic qualities of eight or ten Korean monophthong vowels (i, e, (ɸ), ɛ, (y), ʌ, a, o, ɯ, ɨ) are described by reference to the cardinal vowel system of IPA. There is disagreement among Korean phonologists, however, with respect to the number of monphthongs in modern

standard Korean. According to Lee (1998), the disagreement is due to different views as to whether or not Korean has the front round vowels /y/ and /ɸ/. Korean vowels in the vocal tract are represented in Figure 2 below.

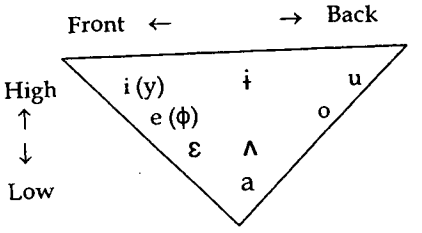

Figure 2. Position of Korean vowels in the vocal tract

Since both Korean and English vowels can be represented by the same phonetic symbols and by similar diagrams shown in Figures 1 and 2, the vowels are recognized by Korean NSs as "identical" or "similar," and as a result, English phonetics are taught with Korean counterpart vowels in institutional settings in Korea.

Vowel sounds transcribed using the same IPA symbol, however, may differ systematically (Flege, Bohn, & Jang, 1997) and vary according to individual speakers, gender, region, dialect, and so on. While examining vocal tract length of male and female Korean and American English speakers, Yang (1992, 1996) indeed found that vowel qualities in English and Korean vary according to gender and nationality.

Lee and Zhi (1987) also measured F1/F2 frequencies of eight Korean vowels (i, e, ɛ, ʌ, a, o, u, ɨ) on the sound spectrograph. The results of their study revealed very similar values to Yang's study (1996). Kil's study (2001), however, showed quite different result from those of Lee and Zhi and Yang. Kil examined the F1/F2 frequencies of /e/, /ɛ/, /ʌ/, and /a/ produced by three different groups (Korean, Spanish, and American English) to investigate the effect of L1-L2 transfer. She found that vowel qualities in the three different groups varied according to the individual and the group. What was interesting in Kil's study was that the Korean /a/ was much higher than the English and Spanish equivalents, and was even higher than the Korean /ʌ/. Thus, Kil's study implies that there must be some sound change taking place.

Vowel Quality and Word-final Stops

Numerous interlanguage studies have been conducted to investigate what L2 learners do when their native language does not allow word-final voiced stops but they encounter final voiced stops in a new language they are learning (e.g., Archibald, 1998; Broselow & Park, 1995; Edge, 1991; Flege & Davidian,

1984; Major, 1996, 2001; Weinberger, 1987; Yavas, 1994). The results of those studies showed that commonly observed linguistic behaviors among L2 learners whose L1 does not have final voiced stops are deletion, epenthesis, and devoicing. According to Major (2001), these phenomena are also observed in children's L1 learning. In the pronunciation of 'dog,' for example, a child may first delete the final consonant resulting in [dɔ], then epenthesize with [dɔga], then suppress epenthesis but devoice [dɔk], and finally reach the adult target pronunciation [dɔg].

Inserting epenthetic /ɨ/ at the end of the words, such as [hedɨ] for 'head' or [bitɨ] for 'beat' is one of the factors that causes pronunciation errors by Korean speakers of English. Broselow and Park (1995) focused their study on epenthetic behavior in Koreans learning English and sought to explain when and why Koreans add an extra vowel. Broselow and Park found that among words that end in the same consonant (e.g., beat/bit, cheap/tip), the epenthetic /ɨ/ is added to the words that have bimoraic vowels (e.g., [bi:tɨ] for 'beat', [tʃi:pɨ] for 'cheap') and not to words that have monomoraic vowels (e.g., [bit] for 'bit', [tip] for 'tip'). Hence, they concluded that the epenthetic /ɨ/ cannot be triggered by the final consonant in the English word, but that it is the quality of the vowel in the word that determines whether epenthesis takes place. Broselow and Park's study, therefore, shows that for Korean speakers of English the preceding vowel quality affects the accuracy of pronouncing the word in the target language.

Some studies (e.g., Edge, 1991; Locke, 1983; Plevyak, 1982; Smith, 1978) on final devoicing in child language and language disorder have also shown that vowel quality influences consonant voicing. While most interlanguage studies have focused exclusively on the sound of the target final voiced stops, one of the earlier studies that took the environment into account in the exploration of misproduction of final voiced stops was Edge (1991). Edge examined the effects of different environments on the production of final stops and stated that the majority of the devoicing cases were found before a pause.

Yavas (1994) focused on the height of the vowel preceding final stops to investigate the relationship between vowel quality and word-final voiced stops, while Edge (1991) was concerned with the environment following the word final obstruents. Yavas' study was spurred by two unpublished master's theses (Parucci, 1983; Plevyak, 1982) that examined the place of articulation of the stops and the effect of the preceding vowel.

Parucci (1983) measured the duration of consonantal closure and voicing by an oscilloscopic analysis of 360 CVC monosyllables whose final stops were preceded by vowels of different heights produced by eight native English speakers. The result of her study revealed that the velar stop /g/ was less voiced than the other voiced stops. This means that the place of articulation affects devoicing. This study, however, did not confirm whether or not different vowel heights influence voicing.

Plevyak (1982) conducted a similar study on final stop devoicing. Eight 3-year-old native English children participated in the study. They produced syllables that contained final stops with different vowels preceding them. This study also confirmed that /g/ was devoiced more than /b/ and /d/ but only in high vowel environments.

According to Yavas (1994), studies on the relationship between vowel height and voicing are based on the idea that high vowels are more prone to devoicing final stops than low ones because the production of high vowels creates higher supraglottal pressure (Jaeger, 1978), and that this vulnerability of high vowel would be carried over to the following stops. Yavas tested this idea with the data from 19 speakers of different languages that do not contain any stop in the final position. Subjects read a list of words all ending in voiced stops preceded by vowels of different heights. From this study, Yavas found that changing the vowel from low to high made a significant difference for the alveolar and velar stops, but not for the bilabial stop. That is, a preceding lower vowel helped non-native speakers produce the voicing of final /d/ and /g/ more accurately.

Major and Faudree (1996) also imply that vowel height may influence consonant voicing and argue that Korean speakers of English have different degrees of difficulty in producing voiced obstruents according to their positions (i.e. initial, medial, final). They do not, however, deal with that matter explicitly since it goes beyond the scope of their study. All of these studies bring us to the present study.

METHOD

Subjects

Two groups of subjects participated in this study. Group 1 consisted of 6 Korean NSs (3 females and 3 males) who were graduate students at a large university in the southwestern United States. The ages of the Korean NSs ranged from 25 to 34 years. They had studied English in Korea for 8 to10 years, and their length of residence in the United States was 3 to 4 months at the time this study was conducted. Group 2 consisted of 6 English NSs (3 females and 3 males) who were students at the same university. Their ages ranged from 19 to 33 years. A panel of four English NSs was used to judge the data that were collected from the 12 subjects.

Speech Materials and Tasks

Two word lists were used in this study: an English word list and a Korean word list. Each list contained monosyllabic words, which had one of the vowels /i/, /ʌ/, or /a/, and were followed by contrastive voiced and voiceless stops, /b/, /d/, /g/, /p/, /t/, and /k/. The English NSs were recorded reading the six English words (top, huck, meet, bob, mug, seed) in isolation so that they

would tend to articulate each sound fully (cf. Flege, Frieda, & Nozawa, 1997; Pennington, 1996).

The Korean NSs were asked to complete two tasks. First, they were recorded reading the same list as the English NSs. Second, they were asked to produce six Korean words that were written with the same IPA symbols as the words in the English list, with the exception that all the stops were unvoiced. That is, since Korean does not have voiced stops, the voiceless stops contrasting to the voiced ones (p↔b, t↔d, k↔g) were substituted: tap (tower), huk (gasp), mit (under), pap (rice), muk (ink), sit (load). In all, 108 tokens produced by 12 participants were used for this study.

Variables

The independent variables in the present study were the acoustic characteristics of English vowels /i/, /ʌ/, and /a/ and their Korean counterparts. The dependent variable was the accuracy of English final stops (p, t, k, b, d, g) produced by native Korean speakers.

DATA ANALYSIS

Data were analyzed in two ways. One analysis was done with a Speech Analyzer Program (SAP). F1/F2 frequencies of each vowel in the 108 tokens that were produced by English NSs and Korean NSs were measured on spectrograms in the SAP. Formant measurements were performed by placing the cursor at the mid-point of the vowel in the center of a formant band on the spectrogram. Females and males were grouped separately because there were significant differences between them in the F1/F2 frequencies they produced. Based on the literature, for example, the possible range of F1/F2 frequencies for males in the case of /a/ is 630/1000 Hz to 750/1350 Hz and for females, 750/1200 Hz to 980/1400 Hz. The comparison, then, was conducted with F1/F2 frequencies of English vowels produced by English and Korean NSs and Korean vowels produced by Korean NSs for the same gender.

The second analysis, performed by four English NSs, was a perception analysis of the speech samples. In order to judge the accuracy of the English presentations, a scoring sheet was designed for each judge to circle the vowel and/or final consonant stop in each word (see Appendix). Judges listened to the recording of the data and circled the vowel and/or final consonant stop and gave a brief explanation of why s/he circled them or not (e.g., the vowel length was short, or the final stop was deleted). When the judges were asked to complete this portion of the study they did not know that the subjects were nonnative speakers of English, or that the Korean subjects were recorded reading two different word lists.

RESULTS AND DISCUSSION

Vowel quality and voicing in native Korean and English female speakers

Since the primary purpose of this study was to investigate English and Korean vowel quality and L1-L2 transfer, a comparison was conducted between English and Korean subjects' F1/F2 frequencies of /a/, /ʌ/, and /i/. Figure 3 below illustrates the different F1/F2 frequencies of the three vowels in Koreans speaking Korean (KK), Koreans speaking English (KE), and native English speakers speaking English (NE). The most dramatic effects on vowel locations via F1/F2 came from differences between individual subjects.

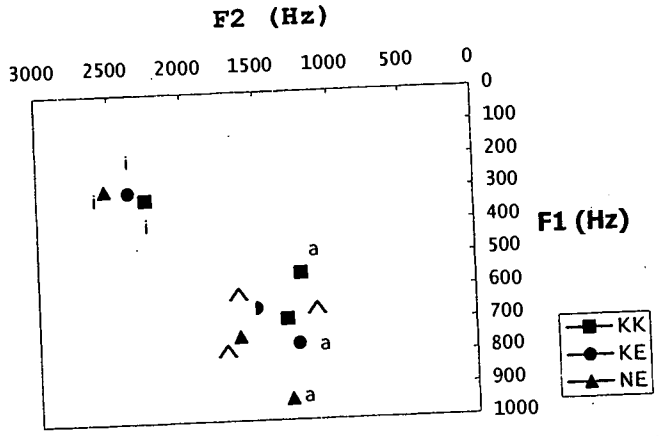

Figure 3. F1-F2 frequencies of test vowels produced by Korean and English female speakers. Phonetic symbols are given near the formant position. [1]

As can be seen in Figure 3, there are substantial differences in F1/F2 frequencies of the vowels between KK, KE, and NE. An interesting phenomenon among the groups is that F1/F2 frequencies of English vowels in KE are superimposed between the KK and the NE sound groups. This means that when Korean NSs articulate English vowels within the oral cavity, they move their tongue position from the articulatory position of Korean vowels to that of English. This shift seems to indicate that Koreans' English approximates somewhat to native English sounds. Taking into consideration the fact that the nonnative subjects in this study had resided in the U.S. for less than four months, it can be presumed that the F1/F2 frequencies of more advanced L2 learners (i.e., somewhat more

[1] F1 (Y-axis) is related to tongue height, while F2 (X-axis) is related to tongue advancement. For example, /i/ is a high and front vowel (a low F1 and a high F2). In contrast, /a/ is a low and back vowel (a high F1 and a low F2).

successful with voicing) might approximate native English sounds even more closely.

Figure 3 also shows that the Korean /a/ is much higher in its articulatory position than the English /a/. This result differs from the results of Lee and Zhi (1987) and Yang (1996), but is similar to Kil's Study (2001). Thus, further research and study needs to be designed and carried out with more subjects to verify the values of F1/F2 frequencies of the Korean /a/.

The pronunciations of 'tap' and 'pap' by KK were determined by the judges as non-native English sounds mainly because of the short vowel length in the case of 'tap' and the final stop in 'pap'. For KE, the words 'top' and 'bob' were also rated by the judges as non-native English sounds, due again to either a short vowel length or a final stop. This result, therefore, may indicate that Yavas's (1994) claim that a preceding lower vowel (e.g., /a/) helps NNSs' accuracy of voiced stops may not be entirely accurate when dealing with Korean female speakers.

While the Korean and the English /ʌ/ and /i/ are located at similar heights, the Korean /ʌ/ and /i/ are further back than the corresponding native English sounds. The judges agreed that all KKs ('huk', 'muk', 'mit', and 'sit') were inaccurate as English sounds because of the short vowel sound and final devoicing and deletion. With KEs ('huck', 'mug', 'meet', and 'seed'), there was disagreement among the judges. Three out of four judges determined that the vowel sounds of the KE were the same as native English, but that the final stop sounds were not native-like due to deletion and epenthetic /ɨ/ at the end of the word. One judge, though, decided that one Korean subject's sound was native-like, although the values of her F1/F2 frequencies were significantly different from native English. In addition, the values of F1/F2 frequencies of one native English subject were quite different from those of the other English subjects, so that one may expect that her sound would be judged as non-native. All of the judges, however, agreed that her sound was native. These factors indicate that F1/F2 frequencies themselves are not the major factor in determining whether sounds are native or non-native and that there are other factors that make the sounds native or non-native (e.g., vowel duration, accent).

An interesting rating was represented in the matter of epenthesis in the word 'seed' as produced by Korean NSs. Two judges determined that all the Korean NSs produced the whole word accurately. The other two judges agreed that one Korean subject was correct, but that the other two were not accurate because of an epenthetic /ɨ/ at the end of the word, [sidɨ]. Apparently the judgment of Korean NSs' pronunciation of 'seed' seemed to come from epenthesis because some judges perceived the final voiced stop produced by Korean NSs as more native-like, and other perceived them as inaccurate representations of English.

'Seed' was the only word among the productions by Korean NSs that showed high accuracy. It is not clear, however, what factor was operating to

enable Korean NSs to produce 'seed' with high accuracy. The high accuracy may have been a result of epenthesis or similar vowel quality.

Consequently, it is difficult to tell what effect the lower vowels have on consonant voicing because Korean female speakers failed to produce the final voiced stops regardless of the height of the preceding vowel. Even though one Korean subject was judged as native-like, it does not prove that vowel height influenced consonant voicing, since her F1 frequency of the lower vowel /a/ was much higher than the English /a/.

Vowel quality and voicing in native Korean and English male speakers

When compared to F1/F2 frequencies of vowels produced by female speakers, the frequencies of male speakers in KK, KE, and NE are grouped in the expected way via the inventory of vowel systems as seen in Figure 4 below.

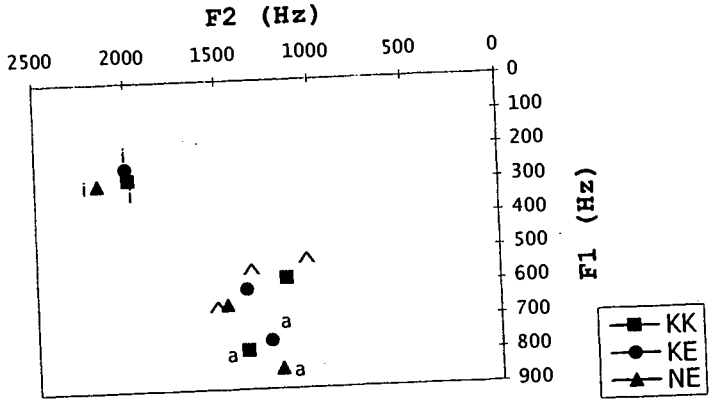

Figure 4. F1-F2 frequencies of test vowels produced by male Korean and English speakers. Phonetic symbols are given near the formant position.

There was a large difference shown between KK and NE. There were also differences between F1/F2 frequencies of the /a/ produced by Korean and English male speakers. The Korean /a/ was much higher and more to the font than the English /a/, but was not as high as seen in Korean female speakers. A noticeable occurrence was that the values of the F1/F2 frequencies of the English /a/ produced by Korean NSs were moving away from the Korean /a/ and toward the native English /a/. These data indicate that Korean NSs may assimilate English vowel sounds in their English speech. In spite of this movement, their frequencies of English /a/ were still different from native English. All the judges determined that the productions of both KK and KE were not accurate representations of the English /a/ for the same reason that they found with Korean female speakers (i.e., the /a/ produced by Korean NSs was somewhat shorter than the English /a/).

The Korean /ʌ/ was also higher and farther back than the English /ʌ/, and the Korean and the English /i/ were almost the same height, but the Korean /i/ was farther back than the English /i/. An obvious judgment was shown with 'huk' and 'muk' in KK and 'huck' and 'mug' in KE. All the judges determined that both the Korean 'huk' and the English 'huck' produced by Korean NSs were not different from native English sounds, but their production of 'muk' and 'mug' was definitely not native English because of the final stop deletion and devoicing.

As in the case of Korean female speakers, an intriguing phenomenon occurred in Korean male speakers of English. 'Meet' in KE was determined by the judges as being inaccurate because of the final coda deletion [mi], while two judges determined that 'seed' in KE was accurate, and the other two judges determined it to be inaccurate because of epenthesis, [sidɨ].

Another noteworthy result was that there were slight differences between the values of the F1/F2 frequencies of vowels preceding voiceless and voiced stops. In most of the Korean subjects, the F1/F2 frequencies of the vowels that preceded a voiced stop were higher than ones that preceded a voiceless stop. In the case of /ʌ/, for example, the F1/F2 frequencies of /ʌ/ preceding the voiced stop in KE were higher than those preceding a voiceless stop. This means that when Korean speakers pronounce a final voiced stop they are likely to produce a preceding vowel that is lower and, as a result, the F1/F2 frequencies of the KE vowel preceding a voiced stop are closer to native English, while the F1/F2 frequencies of /ʌ/,which precedes a voiceless stop in KK and KE, are far away from native English. This tendency may be related to Yavas's (1994) claim that a preceding lower vowel helps L2 learners produce final stops more accurately. This tendency of Korean NSs does not, however, explain whether or not it facilitates Korean NSs' voiced stop accuracy because all of the judges agreed that both Korean and English words produced by Korean males were non-native sounds because of final stop devoicing, epenthesis, and deletion.

CONCLUSION

While the consonant sounds of English are considerably uniform across the dialects of English, the vowel sounds present varieties that bear more problems for ESL/EFL learners (Nasr, 1997). Moreover, when vowel qualities in the native and the target language of the student differ, the problem is exacerbated. Knowing correct vowel qualities and their influence on the environment, therefore, will help both teachers and students to produce correct sounds in a target language. For this reason, a comparative study of vowel qualities in the target and the native language may prove valuable in teaching the language and correcting student errors. Also, quantitative criteria could be used to evaluate students' achievement of correct pronunciation skills in the target language. In this context, the present study examined the quality of English and Korean vowels and the relationship of vowel quality to consonant

voicing to acknowledge the necessity of pedagogical changes in institutional settings in Korea.

This study found that there were substantial differences between Korean and English in the F1/F2 frequencies of vowels. The most significant phenomenon was that the Korean /a/ is much higher than the English /a/. As a result, despite Yavas' (1994) claim that lower vowels influence final stop voicing, most Korean subjects failed to pronounce final voiced stops accurately. On the other hand, the Korean and the English /i/ showed very similar quality, and some voiced and voiceless stops that followed /i/ (e.g., 'seed') produced by Korean NSs were determined by native English judges to be accurate representations of English. This means that the F1/F2 frequencies of the vowels affect the production/perception of an accurate sound, even though it is not certain to what degree they affect consonant voicing.

A noteworthy feature of the study was that the F1/F2 frequencies of Korean males' English vowels were different from their Korean counterparts and shifting toward native English. The shifting was most prominent in the F1/F2 frequencies of vowels that preceded a voiced stop. This observation provides support for the claim that there might be some relationship between vowel height and consonant voicing. Therefore, further research needs to be designed with more subjects and various measurements, and the results need more systematic data analysis to confirm the relationship between vowel quality and consonant voicing.

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Appendix

Please circle the vowel and/or final consonant stop if it sounds non-native. Then, briefly explain why you circled it (e.g., because of the long or short vowel length, or final deletion, devoicing, or epenthesis).

Subject 1

1) o p;	2) uc k;	3) ee t;	4) o b;	5) u g;	6) ee d
(top)	(huck)	(meet)	(bob)	(mug)	(seed)

1) o p;	2) uc k;	3) ee t;	4) o b;	5) u g;	6) ee d
(top)	(huck)	(meet)	(bob)	(mug)	(seed)

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