

## Perception and Production of English Front Vowels by Korean Speakers

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### ABSTRACT

This study investigates the perception and production of English front vowels focusing on the distinction in /i/ vs /ɪ/ and /e/ vs /æ/ by sixty-one Korean speakers. The first portion of this study focused on the perceptual discrimination by the subjects of two sets of English vowel contrasts, /i/ vs /ɪ/ and /e/ vs /æ/. In the second portion of the study, the production of these vowels by the same subjects who had participated in the perceptual discrimination test was examined acoustically and subsequently compared with that of the control group comprised of native English speakers. The major results indicate that: (1) In perception tests, Korean subjects can discriminate between /i/ and /ɪ/ relatively well, while many of them were not able to discriminate between /e/ and /æ/; (2) the Korean subjects, however, have difficulty producing a distinct version of these front vowels; and, (3) The relationship between the perception and production is not significant. These results were analyzed with the concept of "under-differentiation" and "reinterpretation of distinction," as well as how phonetic differences influenced the production and discrimination of front vowels by Korean speakers.

**Keywords:** English front vowels, formants, perception, production

### 1. Introduction

Researchers have claimed that many features of L1 (first language) influence the learning of L2 (second language), and as such an L1 influence is most readily detected in pronunciation (Thompson, 1991). L1 influence in the pronunciation includes "under-differentiation" and "reinterpretation of distinction" (Weinreich, 1953). Here, "under-differentiation" occurs when the L2 has more categories than L1. For example, a native French speaker tends to use /i/ for English /i/ and /ɪ/ because the system of vowels in French has only /i/. "Reinterpretation of distinction" occurs when the L2 speakers distinguish two sounds of L2 by features that are primary in their own L1. For example, when native Jordanian speakers learn English as an L2, they produce

significantly greater ratios of tense to lax vowel durations than native English speakers because they apply Arabic long-short durational patterns when producing English tense and lax vowel pairs.

"Under-differentiation" and "reinterpretation of distinction" have also been observed in Korean learners' perception and production of English vowels due to the phonological differences in the vowel systems of the English and Korean. For example, while Korean only has three front vowels, /i e ε/, English has four frontally located vowels, /i ɪ e æ/.<sup>2)</sup> Therefore, Korean learners struggle to perceive and produce the distinctions between English /i/ and /ɪ/ or /e/ and /æ/ (Bohn & Flege, 1990; Kim, 1994; Flege, Bohn & Jang, 1997; Ingram & Park, 1997; Ku, 1998; Tsukada et al, 2005; Whang & Moon, 2005; Kang, 2007; Yang, 2008).

In addition to the phonological differences, there are also phonetic differences in the pronunciation of Korean and English vowels. Even vowels such as Korean /i/ and English /i/, that

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2) Recently, the phonological 'merging' of two front vowels /e/ and /ε/ has been shown (Hong, 1991).

represent the same phonemic category, occupy somewhat different acoustic space (Yang, 1996; Kim, 2004). Here, English /i/ is produced more frontally and in a higher position than Korean /i/. However, Koreans tend to approximate the English /i/ by producing corresponding Korean vowel, /i/.

Moreover, the inventory of vowel phonemes in English includes so-called “tense” and “lax” distinction. /i/ is truly tense, while /ɪ/, /ɛ/ and /æ/ are typically lax (Jun & Cowie, 1994; Ingram & Park, 1997; Koo, 1998; Ladefoged, 2001; Edwards, 2003; Yang, 2008). Here, the “tense” vowel is defined as being higher and more fronted than the corresponding “lax” one. For example, the English /i/ is produced higher and in a more frontal position than /ɪ/. Some researchers claim that the higher and more fronted vowel is always longer than a lower and more ‘backed’ vowel. For example, English /ɪ/ and /ɛ/ in the h(V)d context are shorter in duration, while the higher and more fronted vowels /i/ and /e/ in the h(V)d context are longer in duration (Peterson & Lehiste, 1960; Klatt, 1976; Bohn & Flege, 1990). On the contrary, such contrast does not exist in Korean. Even though the relationship between vowel formant frequencies and duration varies from that of English, Korean vowels also have a length distinction, which differentiates the meanings. For example, in Korean /i/ means ‘tooth,’ while /i:/ means ‘two,’ and /pi/ means ‘rain,’ while /pi:/ means ‘ratio.’<sup>3)</sup>

This study investigates both perception and production of English front vowels, /i ɪ ε æ/ by native speakers of Korean, focusing on phonological and phonetic distinctions between /i/ vs /ɪ/ and /ɛ/ vs /æ/. Moreover, the relationship between perception and production of these vowels is discussed. Although the relationship between perception and production at the phonemic level is controversial, it may be expected that the listeners who discriminate L2 vowels better produce those vowels better (Ingram and Park, 1997). Whether this assumption is generally valid for Korean speakers’ English vowel production is one of the essential questions of this study.

## 2. Method

### 2.1. Subjects

A total of 61 native Korean speakers (27 males and 34 females) participated for this study.<sup>4)</sup> All were University students

with normal range of hearing and average health. All of them were aged between 18 and 23, were born and educated in Korea, and none had lived in an English-speaking country. In addition to the Korean speakers, five native English speakers (2 males and 3 females) participated, acting as the control group. native English speakers were born in the USA and had moved to Korea after twenty years of age.

### 2.2. Method and material

This study was restricted to two areas of interest. The first portion focused on the perceptual discrimination by the subjects of two sets of English vowel contrasts, /i/ vs /ɪ/ and /ɛ/ vs /æ/. In the second portion of the study, the production of these vowels by the same subjects who had participated in the perceptual discrimination test was examined and subsequently compared with that of the control group comprised of native English speakers. Thereafter, the nature of the relationship between the discrimination ability of these vowels in perception and that of production on the part of Korean and native speakers was discussed.

For the perception test, subjects were directed to mark one vowel they were listening to from among four alternatives: (/i/, /ɪ/, /ɛ/ and /æ/), on a coded response sheet. The listening stimuli were as follows: h(V)d (i.e., *heed*, *hid*, *head*, and *had*) with the target vowel in the medial position and these examples had been recorded by a native English speaker. The native English speaker was male, and originated in northern California. Subjects responded to eight examples of /i/ vs /ɪ/, and eight examples of /ɛ/ vs /æ/ in the discrimination questions. Based on these test scores, subjects were assigned to “high” (scored 5-8) or “low” (scored 0-4) score group in terms of /i/ vs /ɪ/ and /ɛ/ vs /æ/ discrimination, respectively.

In the production test, to elicit the production of the English vowels /i ɪ ε æ/, subjects were asked to read sample sentences aloud, each containing a word h(V)d (i.e., *heed*, *hid*, *head*, and *had*).<sup>5)</sup> All target words were embedded in the carrier sentence: “Say \_\_\_ for me.” Respondents were recorded in a quiet room. Since the subjects required time to become familiar with the test words, the test stimuli were presented and explained before the recording to all participants. All speakers in the testing group were then instructed to read the sentences at a normal,

3) Most younger speakers of Korean do not distinguish such length distinctions, although most know Korean has this feature.

4) The results of males and females are shown separately since the difference of the length of vocal folds of males and females

influence to the acoustic values (Yang, 1996).

5) The target vowels are in a /h(V)d/ context since the fricative /h/ and alveolar /d/ have little influence on vowel formants (Yang, 1996).

self-imposed speed.

Regarding acoustic analysis, the durations and formants of vowels (F1 and F2) were analyzed using Speech Analyzer software (Version 3.0.1). F1 and F2 values were measured using both spectrographic and spectral displays. Vowel steady state was taken to be the middle one-third portion (between “a” to “b” in Figure 1) of the total vowel so that from that position, formant values in the spectrogram were measured (“c” and “d” in Figure 1). Duration of each vowel was measured, using both waveform and spectrogram displays. Vowel onset (“e” in Figure 1) was determined at the point where the amplitude suddenly rose in waveform, and all clearly discernible structures for the first three

To determine the relationship between the vowel distinction in perception and the production, a t-test was performed; here, the dependent variables were F1, F2, duration of front vowels, the distance between /i/ vs /ɪ/ and the distance of /ɛ/ vs /æ/; the independent variables were established by “high” and “low” score groups in perception tests. p-values were appraised as p<0.01 level. In addition, to see more accurate relationship between the perception test scores and the production results, a linear regression test was conducted; here, the dependent variables were F1, F2, duration of front vowels, the distance between /i/ vs /ɪ/ and the distance of /ɛ/ vs /æ/; the independent variables were scores derived from the perception test (p<0.01).<sup>8)</sup>

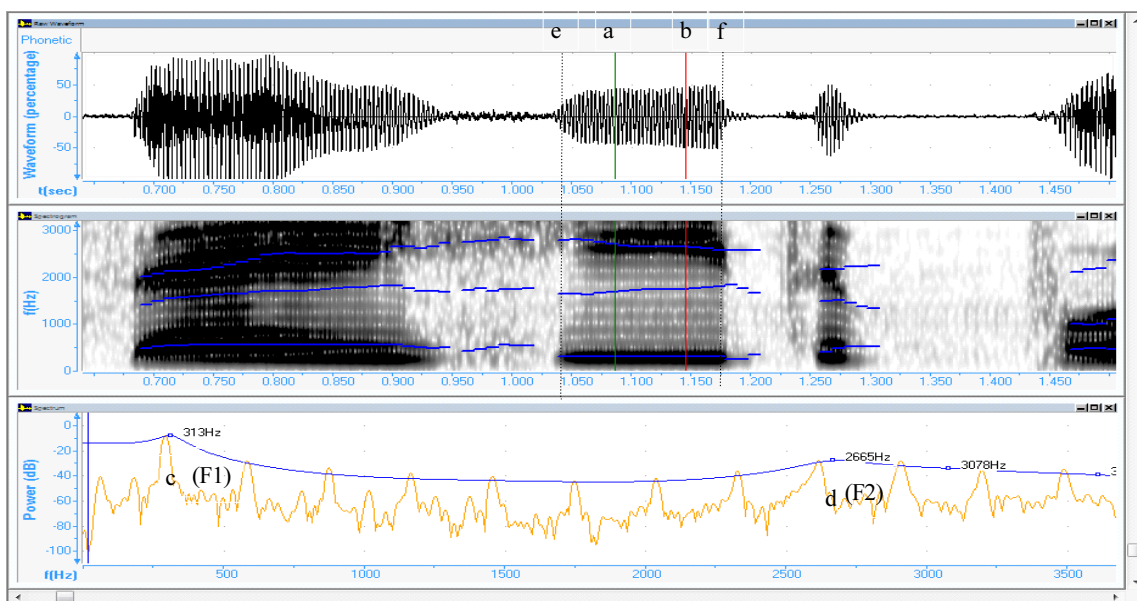


Figure 1. Methods of measuring vowel duration, and F1 and F2; vowel /i/

formants were evident in the spectrogram. Vowel offset (“f” in Figure 1) was determined at the point where the amplitude suddenly fell and clear vowel formant structure disappeared.

In addition, based on the values of F1 and F2, the Euclidean distance between two vowels in each contrast was calculated (i.e., distance between /i/ vs /ɪ/ and /ɛ/ vs /æ/) for each subject. To calculate the Euclidean distance between two vowels, the following formula was used;  $\sqrt{(F1 \text{ of vowel 1} - F1 \text{ of vowel 2})^2 + (F2 \text{ of vowel 1} - F2 \text{ of vowel 2})^2}$ .<sup>6)</sup> To investigate whether the subjects could distinguish two vowels, such methods are used because the values represent the distance between two vowels in the acoustic space of the vowel.<sup>7)</sup>

### 3. Results

#### 3.1. /i/ vs /ɪ/

As expected, in the perception test, all the subjects of the English control group (for both males and females) were assigned to a “high” score group in terms of the discrimination of /i~/ɪ/. Actually, they performed close to 100%. In the case of the Korean male subjects, 93% (n=25) of them were assigned to a “high” score group while only 7% (n=2) of them were categorized as a “low” score group. In the case of the female subjects, 94% (n=32) of them were assigned to a “high” score group while 6% (n=2) of them were categorized as a “low” score group. Here, we can notice that Korean speakers discriminate

6) Euclidean distance was considered and discussed in Tsukada et al. (2005) also.

7) To investigate if the subjects can distinguish two vowels, usually, native English speakers' intelligibility judgement was

used. However, without English speakers' intelligibility judgement, such method may be the best way.

8) Since both dependent and independent variables are not categorized, a Linear Regression analysis was used.

English /i/ and /ɪ/ relatively well in tests of perception.

In tests of production, however, Korean speakers have difficulty in distinguishing English vowels /i/ and /ɪ/. Table 1 presents the mean values of F1, F2 and duration for the English vowels /i/ and /ɪ/ and the calculated Euclidean distance between /i/ and /ɪ/ as produced by “high” and “low” score groups and control group respectively. Here, we can notice that the mean F1 and F2 values of both “high” and “low” groups are generally different from those of control group. In terms of duration, it is noticed that the mean durations of /i/ and /ɪ/, as produced by all male and female “high” and “low” groups, were much shorter than that of the English vowel durations as produced by male and female control groups.

Table 1. The mean vowel formants (Hz) and duration (ms) of the English vowels /i/ vs /ɪ/ and the calculated distance between /i/ and /ɪ/ as produced by three groups for males (m) and females (f)

	Vowel	Group	F1 (sd)	F2 (sd)	duration (sd)
m	/i/	high	339.88 (47.08)	2187.44 (146.41)	142.32 (48.66)
		low	330.00 (2.82)	2094.50 (467.39)	121.00 (63.63)
		control	270.00 (14.14)	2275.00 (35.35)	210.00 (42.42)
	/ɪ/	high	345.92 (56.58)	2149.80 (144.98)	103.60 (46.10)
		low	338.00 (32.52)	1914.00 (148.49)	87.50 (26.16)
		control	395.00 (7.07)	1940 (56.56)	212.5 (95.45)
	/i/∞/ɪ/	high	119.17 (91.63)		
		low	231.07 (247.87)		
		control	357.69 (17.39)		
f	/i/	high	380.37 (82.46)	2514.65 (305.45)	132.71 (66.66)
		low	426.50 (70.00)	2546.50 (28.99)	141.50 (28.99)
		control	253.66 (25.10)	2525.00 (263.28)	214.33 (91.34)
	/ɪ/	high	386.75 (77.86)	2496.84 (311.73)	114.00 (52.15)
		low	476.00 (33.94)	2473.00 (28.28)	147.50 (23.33)
		control	432.00 (26.22)	2114.33 (222.87)	140.66 (29.14)
	/i/∞/ɪ/	high	131.14 (110.21)		
		low	121.92 (7.67)		
		control	448.25 (66.65)		

(sd): standard deviation

With regard to the calculated acoustic distance between /i/ and

/ɪ/, the mean distance of male “high” score group was 119 and that of male “low” was 231. The mean distance of female “high” score group was 131 and that of female “low” was 121. On the other hand, those of male and female control groups were 357 and 448 respectively, and these values are considerably larger than those of the Korean groups (Figure 2).<sup>9)</sup>

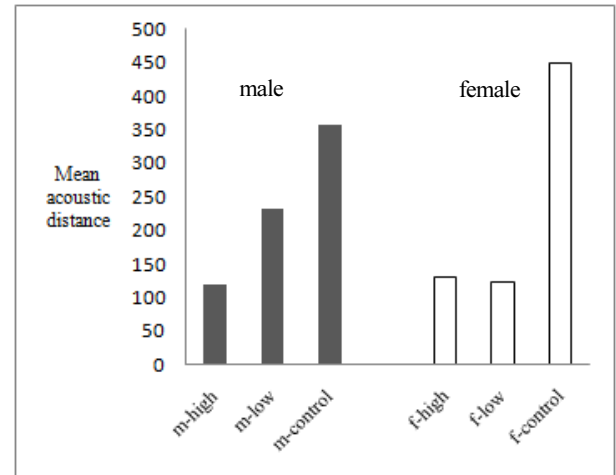


Figure 2. The calculated distance between /i/ and /ɪ/ of “high”, “low” and control groups.

When we compare the results of “high” and “low” score groups, we can notice that in all features of production, there is no significant difference between “high” and “low” score group ( $p>0.01$ ). Table 2 shows the result of t-test.

Table 2. The result of the t-test comparing the mean vowel formants (Hz) and duration (ms) of the English vowels /i/ vs /ɪ/ produced by “high” and “low” score groups

	Vowel	t	F1	F2	duration
m	/i/	t	.291	.280	.588
		p	.773	.826	.562
	/ɪ/	t	.193	2.211	.482
		p	.848	.036	.634
	/i/∞/ɪ/	t	-.635		
		p	.638		
f	/i/	t	-.771	-.145	-.183
		p	.446	.885	.856
	/ɪ/	t	-1.593	.107	-.892
		p	.121	.916	.379
	/i/∞/ɪ/	t	.117		
		p	.908		

9) Here, the calculated distance between /i/ and /ɪ/ is more meaningful than mean value of F1 and F2, because F1 and F2 values differ by the subjects. Since this study focuses on the distinction itself, such calculated distance includes its obverse distinction, that is /ɪ/ is fronted and raised than /i/.

In addition to the t-test, to investigate the relationship between individual perception score and the acoustic values of production, Linear Regression analysis was conducted (See Tabel 3). The results of the Linear Regression analysis also shows that perception and production are not interrelated (r-squares are very low).

Table 3 The result (R-square) of the Linear Regression analysis to determine the relationship between the scores of the perception test and acoustic values of production for vowels /i/ vs /ɪ/

	Vowel	F1	F2	duration
m	/i/	.001	.016	.013
	/ɪ/	.027	.080	.005
	/i/∅/ɪ/	.089		
f	/i/	.000	.000	.012
	/ɪ/	.021	.001	.007
	/i/∅/ɪ/	.002		

3.2. /e/ vs /æ/

As with the /i/ vs /ɪ/ discrimination test, in the /e/ vs /æ/ discrimination test, all subjects in English control group were assigned to a “high” score group. However, 37% (n=10) of the Korean male subjects were assigned to a “high” score group, while 63% (n=17) of them were assigned to the “low” score group. In the case of female subjects, only 9% (n=3) were “high” score group while 91% (n=31) were “low” score group. These results indicate that many Korean speakers cannot discriminate between the English vowels /e/ and /æ/.

Likewise, in the case of the production of /e/ vs /æ/, Korean speakers had difficulty in distinguishing these vowels. Table 4 presents the mean values for F1, F2 and duration of the English vowels /e/ and /æ/ and the calculated distance between /e/ and /æ/ as produced by three groups, which are assigned based on the results derived from the /e/ and /æ/ perception test. Here, we can notice that the mean F1 and F2 values of both “high” and “low” score groups are generally different from those of control group. In terms of duration, the mean durations of /e/ and /æ/, as produced by both “high” and “low” score groups, were much shorter than that control group.

Table 4. The mean vowel formants (Hz) and duration (ms) of the English vowels /e/ vs /æ/ and the calculated distance between /e/ and /æ/ as produced by three groups for males (m) and females (f).

	Vowel	Group	F1 (sd)	F2 (sd)	duration (sd)
m	/e/	high	601 (50.53)	1771.40 (274.86)	108.30 (19.68)
		low	575.76 (77.30)	1754.11 (92.98)	136.58 (44.27)
		control	550.00 (.00)	1775.00 (106.06)	181.00 (26.87)
	/æ/	high	560.80 (78.38)	1761.60 (196.07)	101.70 (32.70)
		low	572.70 (80.78)	1750.35 (99.64)	114.41 (43.75)
		control	690.00 (14.14)	1625.00 (106.06)	275.00 (77.78)
	/e/∅/æ/	high	123.39 (82.36)		
		low	80.36 (53.21)		
		control	205.31 (9.64)		
f	/e/	high	674.33 (46.45)	2024.33 (236.56)	124.33 (24.17)
		low	644.64 (155.55)	2063.25 (205.42)	141.16 (47.84)
		control	628.66 (2.30)	1951.66 (249.81)	169.00 (46.22)
	/æ/	high	602.33 (77.02)	2105.33 (210.03)	122.66 (31.02)
		low	600.51 (165.59)	2081.41 (182.74)	119.74 (33.26)
		control	801.33 (16.28)	1831.66 (189.89)	221.33 (59.67)
	/e/∅/æ/	high	121.68 (38.38)		
		low	122.94 (78.07)		
		control	213.46 (50.12)		

(sd): standard deviation

With regard to the calculated acoustic distance between /e/ and /æ/, the mean distance of male “high” group was 123 and that of male “low” was 80. The mean distance of female “high” group was 121 and that of female “low” was 122. On the other hand, those of male and female control groups were 205 and 213 respectively and these values are much larger than those of Koreans (Figure 3).

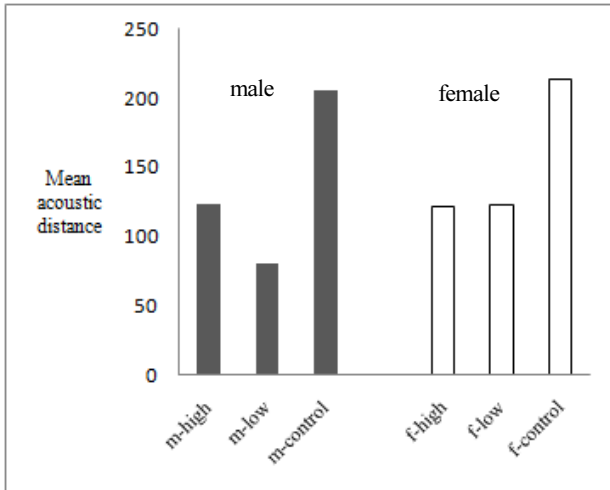


Figure 3. The calculated distance between /ɛ/ and /æ/ of “high”, “low” and control groups.

When we compare the results of “high” and “low” score groups, we can notice that in all features of production, there is no significant difference between “high” and “low” score group ( $p > 0.01$ ). Table 5 shows the result of t-test.

Table 5. The result of the t-test comparing the mean vowel formants (Hz) and duration (ms) of the English vowels /ɛ/ vs. /æ/ produced by “high” and “low” score groups

	Vowel		F1	F2	duration
m	/ɛ/	t	.948	.240	-1.901
		p	.352	.813	.069
	/æ/	t	-.372	.199	-.795
		p	.712	.844	.434
	/ɛ/∅/æ/	t	1.684		
		p	.104		
f	/ɛ/	t	.325	-.310	-.596
		p	.747	.758	.556
	/æ/	t	.019	.214	.146
		p	.985	.832	.885
	/ɛ/∅/æ/	t	-.027		
		p	.978		

The result of the Linear Regression analysis also shows that the individual perception score and production of /ɛ/ and /æ/ are not interrelated for all features.

Table 6 The results (R-square) of the Linear Regression analysis to determine the relationship between the scores of the perception test and acoustic values of the production; vowels /ɛ/ vs. /æ/

	Vowel	F1	F2	duration
m	/ɛ/	.018	.005	.074
	/æ/	.003	.005	.000
	/ɛ/∅/æ/	.039		
f	/ɛ/	.134	.038	.034
	/æ/	.142	.056	.069
	/ɛ/∅/æ/	.019		

#### 4. Discussion

The finding mentioned above reveals that Korea speakers less distinguish English /i/ vs /ɪ/ and /ɛ/ vs /æ/ than native English speakers do. In other words, Korean speakers may “under-differentiate” English front vowels. This finding conforms to Weinreich’s claim (1963) that under-differentiation of phonemes occurs when two sounds of L2 are not distinguished in L1. In the Korean vowel system, the number of Korean front vowels is less than that of English and importantly there is no distinction of /i/ vs /ɪ/ and /ɛ/ vs /æ/ as is done by native English speakers. Korean speakers fail to distinguish these vowels due to L1 interference in vowel production. Phonetically, when we compare the F1 and F2 values of each vowel, we can notice that Korean speakers have difficulty in producing English vowel /ɪ/ and /æ/ in that they produce these vowels in higher and more frontal positions than native English speakers. In addition, they produce /i/ in lower position than native English speakers. This phenomenon causes the distinctions between /i/ vs /ɪ/ and /ɛ/ vs /æ/ to be blurred when Korean speakers produce these vowels. In addition, this phenomenon results in vowels produced within a smaller acoustic space (that is, the distance between the lowest and highest English front vowels /i/ to /æ/) than that shown by evidence derived from native speakers of English.

With regards to the perception of front vowels, Korean speakers discriminate /i/ and /ɪ/ relatively well, while many of them cannot discriminate between /ɛ/ and /æ/. When we consider the fact that the durational difference between /i/ and /ɪ/ is longer than the duration of /ɛ/ and /æ/, we can infer that such a result is caused by Korean speakers’ “reinterpretation of distinction.” In other words, the reason that Koreans can discriminate /i/ and /ɪ/ relatively well may be attributed to the fact that they discriminate English /i/ and /ɪ/ by means of the long-short duration, not by reference to tense-lax distinctions of English (L2).

With regards to the relationship between the perception and production, the results show no significant difference. Even with subjects who discriminated vowels well in perception, they failed to distinguish contrasting vowel pairs in production. The reason for this may be that in the case of the perception, students can discriminate the sounds by means of part of their features (i.e., only durational difference), while a native speaker has recourse to all the features of the vowels (i.e. height, degree of fronting, degree of rounding, and duration) sound to produce a given vowel correctly. This suggests that even if Korean speakers understand the differences between contrastive English vowels, they cannot ascertain the differences precisely, owing to L1 interference.

### 5. Conclusions

The current study has investigated the perception and production of four English vowels, focusing on the distinctions between /i/ vs /ɪ/ and /ɛ/ vs /æ/ on the part of Korean speakers. The result of this study contributes to our understanding of the various important characteristics of Korean speakers' English front vowel perception and production, suggesting some possible reasons for the observed difficulties. In addition, it shows the relationship of perception and production with respect to the pairs /i/ vs /ɪ/ and /ɛ/ vs /æ/.

The major findings of this study are as follows:

(1) In perception testing, Korean speakers discriminate /i/ and /ɪ/ relatively well, while many of them cannot discriminate between /ɛ/ and /æ/. The result may be caused by the "reinterpretation of distinction," since Korean speakers discriminate English /i/ and /ɪ/ by duration as they do in Korean, rather than relying on other features of the vowels (height, degrees of fronting and rounding) available to native speakers.

(2) Korean speakers "under-differentiate" English front vowels, so that they have trouble producing a distinct version of English /i/ vs /ɪ/ and /ɛ/ vs /æ/ as compared with native speaker. In addition, they produce /ɪ/ and /æ/ in higher and more frontal positions and /i/ in lower position than native English speakers, and these phenomena may result in the reduction of vowel category and acoustic space of English front vowels.

(3) Further, the relationship between the perception and production was not significant. These phenomena mean that even those subjects who are skilled at perception may not be adept at production, implying that they are not fully able to understand the acoustic characteristics of English vowels, and are thus limited in

their ability to produce the target vowels correctly. This study suggests that in order to improve Korean speakers' perception and pronunciation, they must first master the phonological system of the English and learn the acoustic differences between Korean and English. To this end, the pronunciation education curriculum should include teaching and training in the acoustics of phonetic theory to aid both teachers and students. For example, if students learn how the mean degree of height and fronting of English vowels, and how Korean vowels differ, even in vowels such as X or Y represented by the same phonetic symbol, they may learn to produce English vowels near those of native English speakers, and not by relying upon the same quality in corresponding Korean vowels. It seems evident that understanding the degree of fronting and rounding and differences of vowel height between Korean and English will also assist them. For example, this study has determined that Korean speakers generally cannot produce the English /æ/ because the vowel height of /æ/ produced by native English speakers is much lower than the /æ/ produced by native Korean speakers. If Korean students are able to incorporate this acoustic fact, and are trained, as an instance, to shift their jaws downwards production of the English vowel /æ/ may improve.

In the future, a further study containing more elaborated perception and production testing, targeting additional features and vowels, will be needed to enlarge the usefulness of this study.

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