

An Acoustic Study of Relative Articulatory Positions of English Vowels and Korean Vowels*

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ABSTRACT

American English vowels and Korean vowels were compared by the plotformant method. For American English vowels, six General American English speakers pronounced English words in the b_t environment. For Korean vowels eight Kyongsang dialect speakers and eight Seoul dialect speakers pronounced Korean words in the environments of k_t, p_t and t_t. The formant plots were obtained by plotting F1/F2 tokens of 13 American English vowels on the F1x F2 plane. In spite of personal variations the 13 vowel spaces of all six American English speakers maintained their relative positions with some overlaps. Clear distinctions were made between i-ɪ, e-ɛ, u-ʊ, and o-ɔ. The domain of ɔ and ɑ overlapped for three American English speakers, but it did not for three other speakers. The 8 Korean vowel spaces of Kyongsang dialect speakers and Seoul dialect speakers were very similar and maintained their relative positions. No distinction was made between e and ɛ. In contrast with American English ə which is a neutral vowel, Korean ɐ was a back vowel. The comparison of 13 American English vowel positions and 8 Korean Vowel positions is expected to shed some light on the errors of English vowel pronunciation of Korean learners.

Keywords: Formants, Plotformant, F1/F2, English Vowels, Korean Vowels

1. Introduction

This paper purports to compare American English vowels and Korean vowels using the plotformant method which shows the vowel spaces on the F1x F2 plane and use the result to diagnose vowel pronunciation errors of Korean students' English. The advantage of using the plotformant program is that it shows the relative positions of vowels visually by circling the distributions of F1/F2 tokens. As it shows all the distributions together with the mean point of each vowel, it is easy to see the degree of the overlaps and distributional spaces.

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In Hagiwara's study (1995) of English vowels, there was a wide difference between /i/ and /ɪ/ in both men's and women's F1 and F2. The /i/ was closer to /e/ in F1 for both women and men. The F1 values of /i/ and /e/ were 467 and 440 respectively for women, and 418 and 403 for men. Their F2 values of /i/ showed more centralizing tendency with its F2 2400 for women and 1807 for men while the F2 of /e/ was 2655 for women and 2059 for men. (Compare them in Figure 1). The difference between /e/-/ɛ/, and between /ɛ/-/æ/ were significant. The high back vowels /u/ and /ʊ/ overlapped considerably for women, but for men they were completely separated. There were some overlaps between /ʊ/ and /o/ for both women and men, but the /o/ and /ɑ/ were clearly separated.

In Yang's study (1996) of Korean vowels, there were three distinct back vowels /u/, /o/, /ʌ/, two distinct central vowels /ɨ/, /a/, and three front vowels /i/, /e/, /ɛ/. His data suggested that the distinction between /e/ and /ɛ/ is being lost in Korean especially among women (p. 257).

In Cho et al.'s Korean study of Cheju dialect (2000), there were three front vowels /i/, /e/, /æ/, three central vowels /ɨ/, /ə/, /a/, and three back vowels /u/, /o/, /ʌ/. They were suggesting that the mergers of e/æ (also transcribed as e/ɛ) and o/ʌ (o in *tol* 'rock', ʌ in *tal* 'moon') are in progress in Cheju (p. 89).

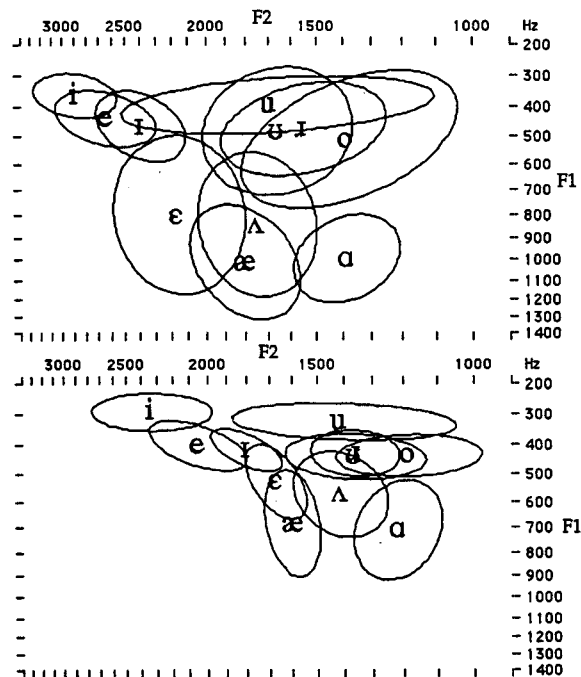


Figure 1. American English Vowels: The women's F1×F2 vowel space (top) and the men's F1×F2 space (bottom) (Hagiwara, 1995, p. 40)

2. Methods

2.1 Subjects

The subjects for English vowels were 6 American English speakers all of whom were born and raised in the midwestern area of the United States. All of them were English lecturers teaching at universities in Busan.

The subjects for Korean vowels were two dialect speakers: Kyongsang dialect and Seoul dialect. Eight speakers in Busan were students at Pukyong National University who were born and attended elementary and secondary schools in Busan and the surrounding Kyongsangnamdo areas. Eight Seoul dialect speakers were Seoul National University students who were born in Seoul and attended elementary and secondary schools in Seoul.

2.2 Words for Experiments

The words used for the English vowel experiment were real English words rather than artificial phonetic creations used for each vowel. Both English and Korean vowels were between stops. English words were in the environment of b_t as shown in Table 1. The words were spoken in the sentence "Say _____ again." Each word had ten tokens and the words were randomized in the list so that the speakers do not know the target words.

Table 1. English Vowels and Words

Vowels	Words
/i/	beat
/ɪ/	bit
/e/	bait
/ɛ/	bet
/æ/	bat
/u/	boot
/ʊ/	book
/o/	boat
/ɔ/	bought
/ɑ/	bottle
/ɜ/	bird
/ə/	battalion
/ʌ/	bud

Korean vowels were obtained in real words as in Table 2. They were in k_t, p_t and t_t environments. Each word was pronounced ten times so that each vowel had 30 tokens. Those words were also randomized in the list so that the speakers do not know

the target sounds. As the preceding or following vowels affect the vowel formants of the target vowels, the words were carefully selected so that the following or preceding syllable had the same vowel as in the words, *daedaejang* (captain), *kodo* (old city), *todohi* (boldly), *podo* (report), *kada* (go), *pada* (sea), *tatami* (mattress), *kudu* (shoes), *pudu* (pier), *tudunhada* (favor), *tidida* (step), *teodeouk* (even more), *peodeong* (waste land), etc.

Table 2. Korean Vowels and Words in the k_t, p_t, t_t Environments¹⁾

	k_t	p_t	t_t
/i/	kido (pray)	pidan (silk)	tidida (step)
/e/	padagedari (crab's leg)	puleulpeda (cut the grass)	pulededa (burnt)
/ɛ/	ibuleulgaeda (fold sheet)	paedal (delivery)	taetaejang (captain)
/u/	kudu (shoes)	pudu (pier)	tutunhada (favor)
/i/	keudaji (not very)	kippeuda (pleased)	teudioe (finally)
/o/	kodo (old city)	podo (report)	todohi (boldly)
/a/	kada (go)	pada (sea)	tadami (mattress)
/ə/	keodaedosi (big city)	peodeong (waste land)	teodeouk (even more)

2.3 Recording Method

Both English and Korean words were recorded using the CSL at the language laboratory at Seoul National University and Pukyong National University. They were spoken a little slower than the normal speed.

3. Results

The formant values were measured by the researcher himself and measuring errors were minimized.

3.1 The vowels of English

Figures 2-7 show the vowel distribution of six American English speakers on the F1 × F2 plane. Figure 8 is the combined formant plot of five speakers' vowel spaces. The spaces of five front vowels were similar to Hagiwara's (1995) shown in Figure 1. The difference between /i/ and /ɪ/ was striking: F1 237 and 383, and F2 2290 and 1852 respectively. The /i/ and /e/ were very close or partly overlapped with means of F1 383 and 381, and F2 1852 and 2041 respectively. The distinction between /e/-/ɛ/, and between

1) The /e/ in Korean in this study is different from the /e/ in American English in which /e/ is a diphthong as in the word *bait*. But the /e/ in Korean is a simple vowel which comes from the IPA symbol chart.

/ɛ/-/æ/ was clear in all six speakers' formant plots. There were personal variations in five back vowels. The difference of vowel spaces between /u/ and /ʊ/ was also striking: F1 282 and 399, and F2 1043 and 960 respectively. The /ʊ/ and /o/ overlapped substantially, which was also evident in Hagiwara's formant plot in Figure 1. The /ɔ/ and /ɑ/ overlapped for three speakers and for the other three speakers they were separated. The three central vowels /ə/, /ɜ/, and /ʌ/ were all centrally positioned and their distributions were quite consistent.

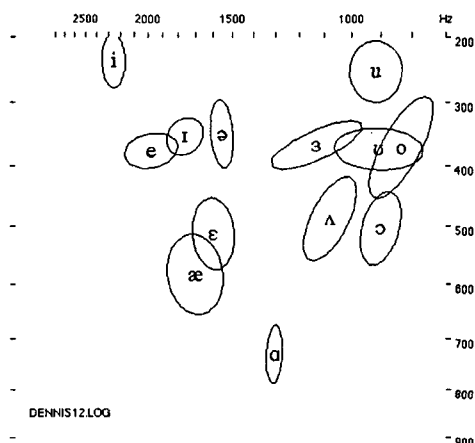


Figure 2. American English speaker 1

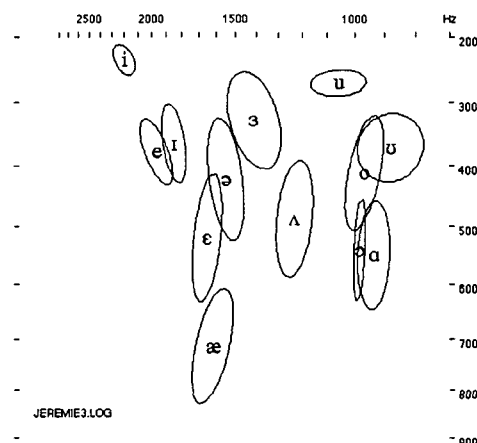


Figure 3. American English speaker 2

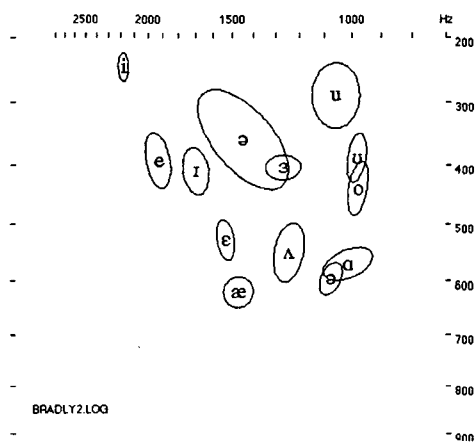


Figure 4. American English speaker 3

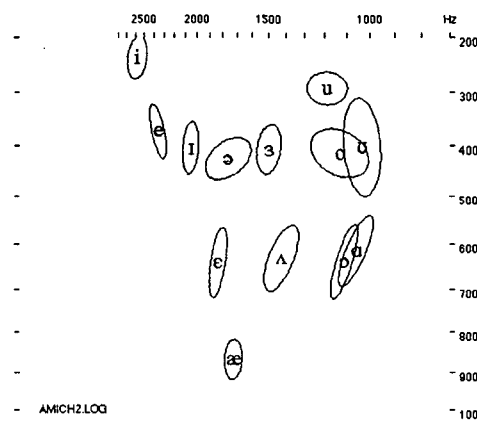


Figure 5. American English speaker 4

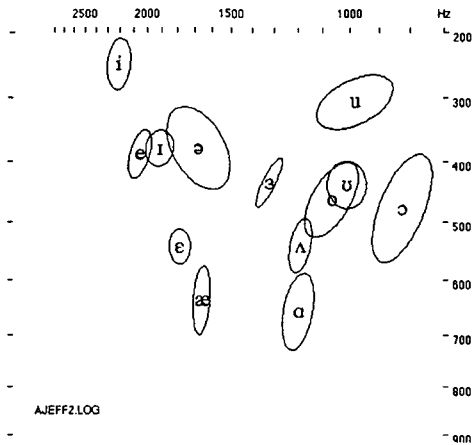


Figure 6. American English speaker 5

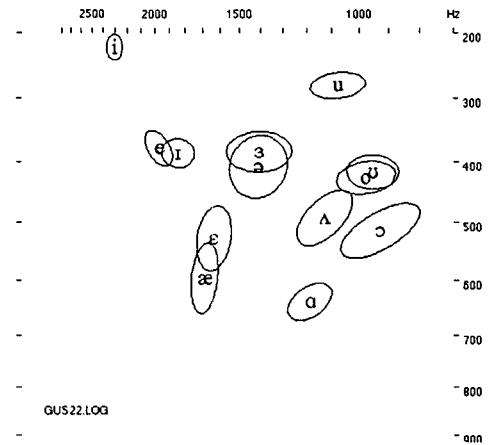


Figure 7. American English speaker 6

In Figure 8 each vowel had 60 tokens with each vowel pronounced ten times by six speakers.

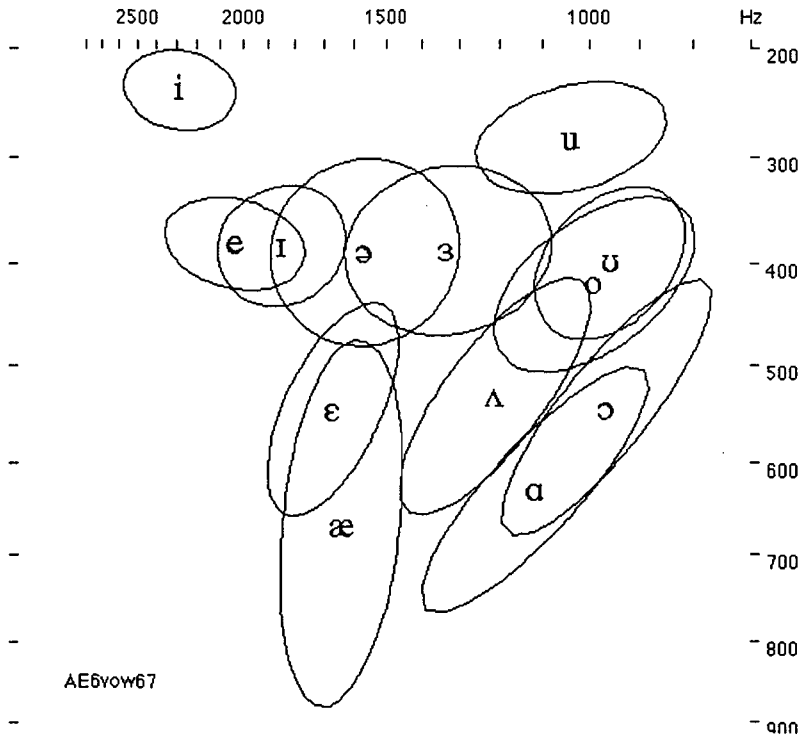


Figure 8. Combined Formant plot of English Vowels of 6 American English Speakers

3.2 Korean Vowels

Figures 9-16 show the formant plots of Kyongsang dialect speakers and Figures 17-24 show the formant plots of Seoul dialect speakers. Generally eight Korean vowels had a triangular shape with /i, a, u/ at the corners while English vowels had a rectangular shape with /i, æ, a, u/ at the corners as seen in Figures 8, 25 and 26. The same phenomenon was found in Yang's study (1996, p. 256). Figures 25 and 26 show that there are no significant differences in vowel spaces between Kyongsang dialect speakers and Seoul dialect speakers. All six vowels /i, i, u, o, ə, a/ have their own distinct spaces on the plot except e/ε which agree with Yang's study (1996).

About /e/ and /ε/, no distinction was found either in Kyongsang dialect or Seoul dialect. The overlaps between the two vowels appeared unquestionable with means of F1 428 and 442, and F2 2173 and 2165 in Kyongsang dialect (Table 4), and with means of F1 458 and 504, and F2 2109 and 2052 in Seoul dialect (Table 5). In Yang's study, the data showed that Korean female speakers did not make the distinction between the two vowels, but male speakers showed a substantial distance between them. In Cho et al.'s study (2000), speakers in Cheju island also did not make any distinction between /e/ and /æ/ (the same as /ε/). They were suggesting that "the mergers of the two vowels are in progress" (p. 89). The /e/ and /ε/ merger seems to be general in Korean.

It was debated in the studies whether English non-phoneme vowel /ə/ and Korean full vowel /ə/ are similar in the relative vowel positions (Ahn, 2000). In Ahn's study (2000), the non-phoneme English /ə/ tended to merge to the neutral tongue position of F1 456 and F2 1560, while the mean points of the Korean /ə/ were F1 548 and F2 998 in Seoul dialect speaker's case and F1 357 and F2 1373 in Kyongsang dialect speaker's case. It was not quite resolved whether it is a back vowel or a central vowel, In Kang's study (1996), in Seoul speakers' case the range of F1 and F2 of /ə/ (transcribed /Λ/ in Kang's paper) was 400-500 and 400-600 respectively, which suggests that it is a back vowel. In Kim and Lee's study (2001), /ə/ had the vowel space of F1 560 and F2 990, which also suggests that it is a back vowel. In the present study, the data in all eight Kyongsang dialect speakers and all eight Seoul dialect speakers suggested that it is a back vowel with the means of F1 427 and F2 932 in Kyongsang dialect speakers' case and F1 573 and F2 945 in Seoul dialect speakers' case (See Figures 25, 26, and Tables 4, 5).

3.2.1 Formant plots of Kyongsang dialect speakers in Korea

In Figures 9-16 each vowel had 30 tokens with each vowel pronounced ten times in three environments k_t, p_t, and t_t.

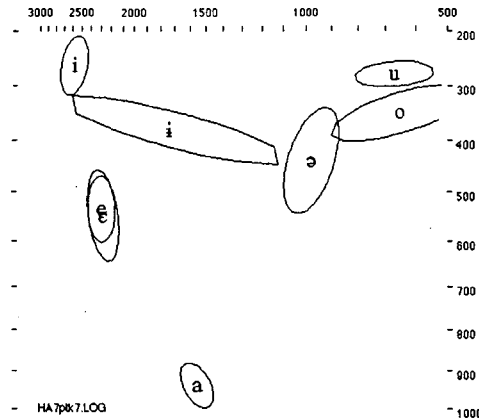


Figure 9. Kyongsang Dialect Speaker 1

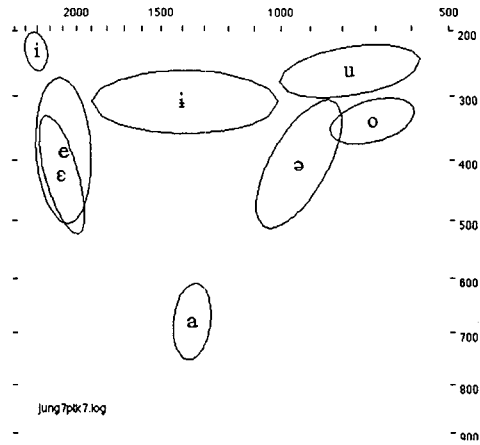


Figure 10. Kyongsang Dialect Speaker 2

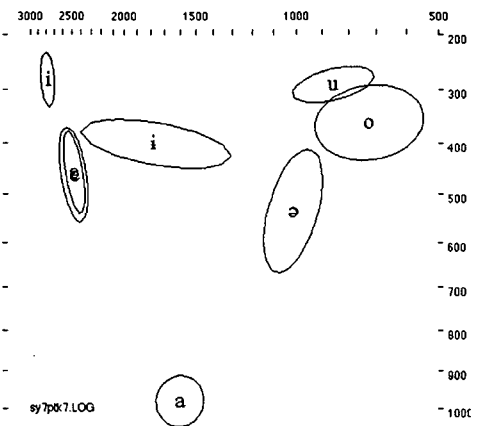


Figure 11. Kyongsang Dialect Speaker 3

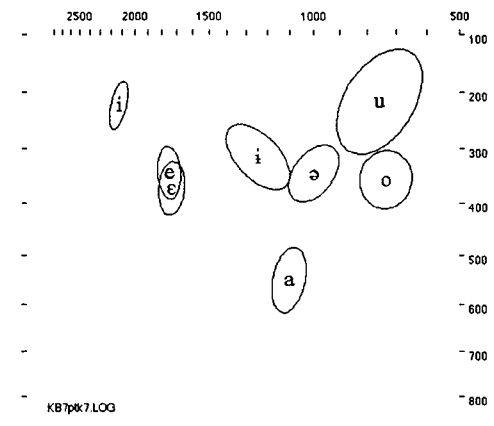


Figure 12. Kyongsang Dialect Speaker 4

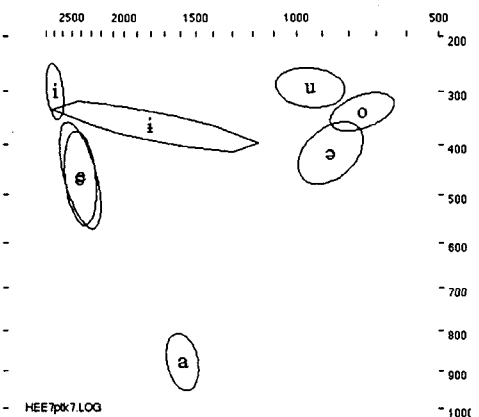


Figure 13. Kyongsang Dialect Speaker 5

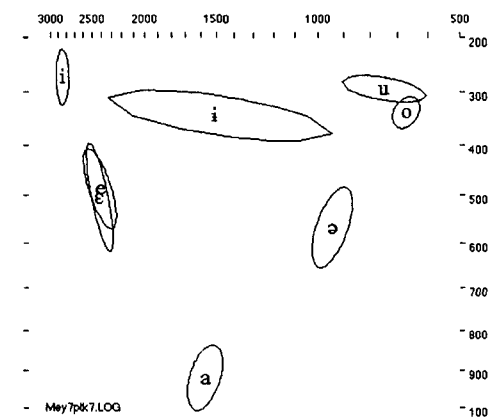


Figure 14. Kyongsang Dialect Speaker 6

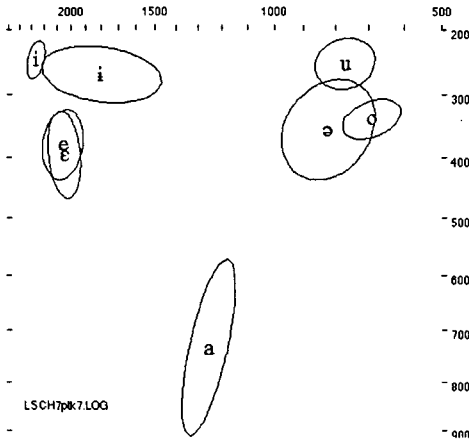


Figure 15. Kyongsang Dialect Speaker 7

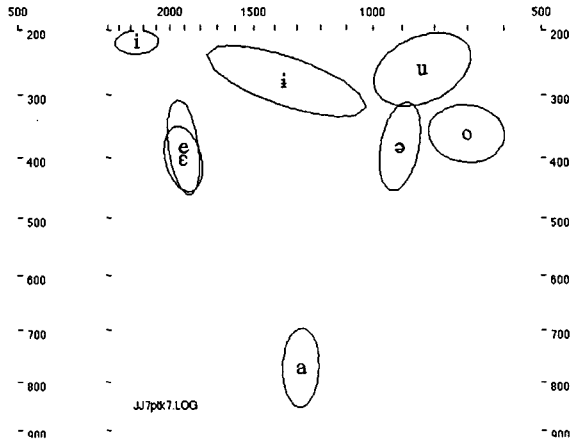


Figure 16. Kyongsang Dialect Speaker 8

3.2.2 Formant plots of Seoul dialect speakers in Korea

In Figures 17-24 each vowel had 30 tokens with each vowel pronounced ten times in three environments k_t, p_t, and t_t.

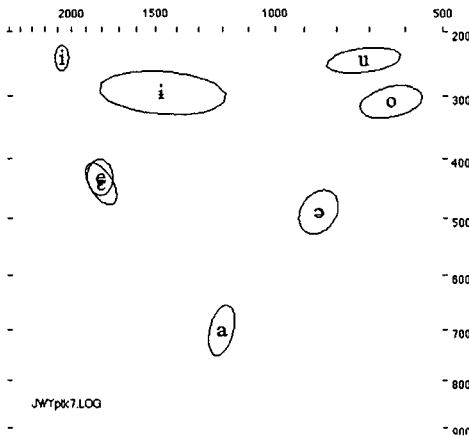


Figure 17. Seoul Dialect Speaker 1

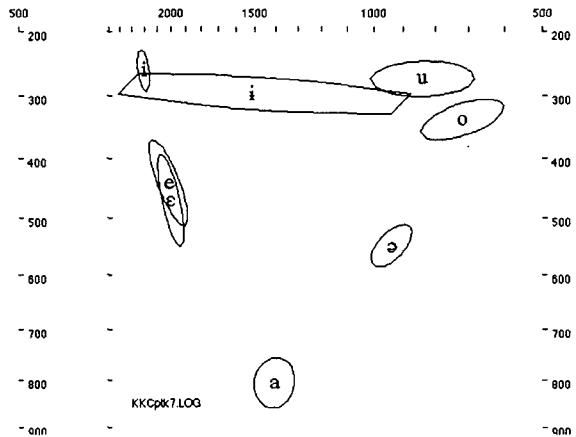


Figure 18. Seoul Dialect Speaker 2

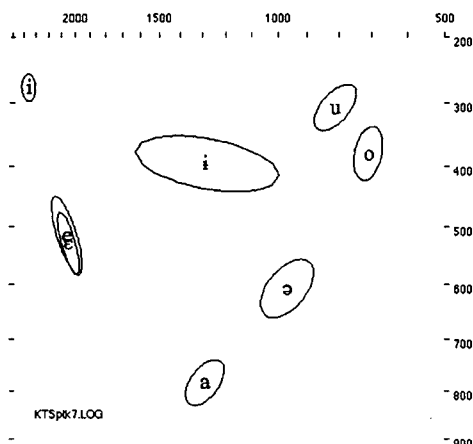


Figure 19. Seoul Dialect Speaker 3

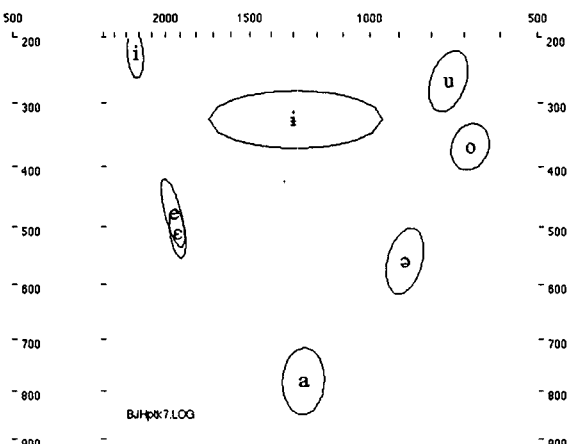


Figure 20. Seoul Dialect Speaker 4

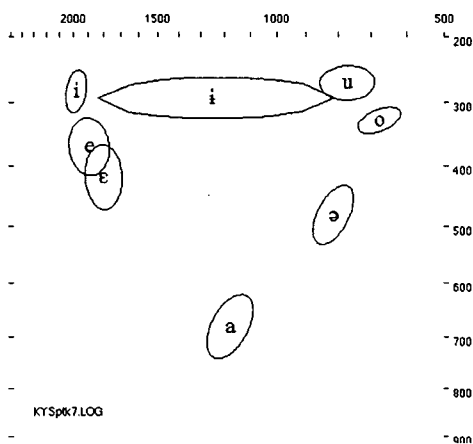


Figure 21. Seoul Dialect Speaker 5

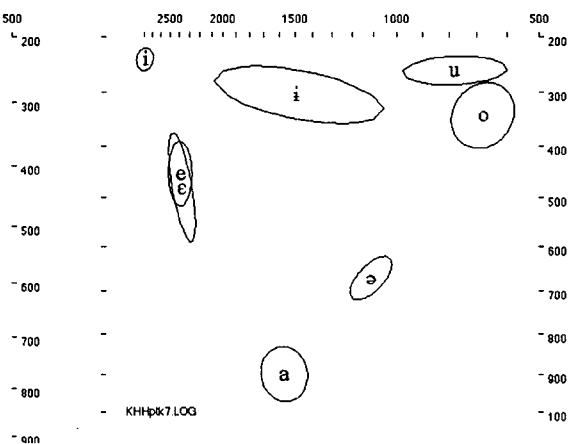


Figure 22. Seoul Dialect Speaker 6

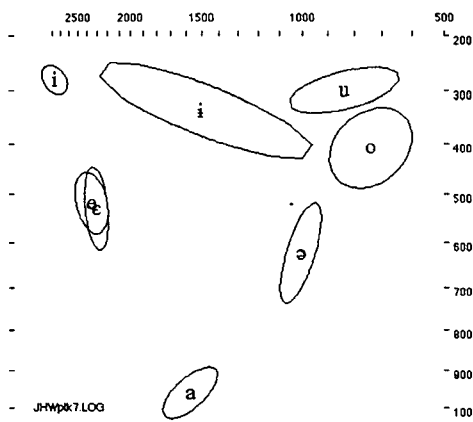


Figure 23. Seoul Dialect Speaker 7

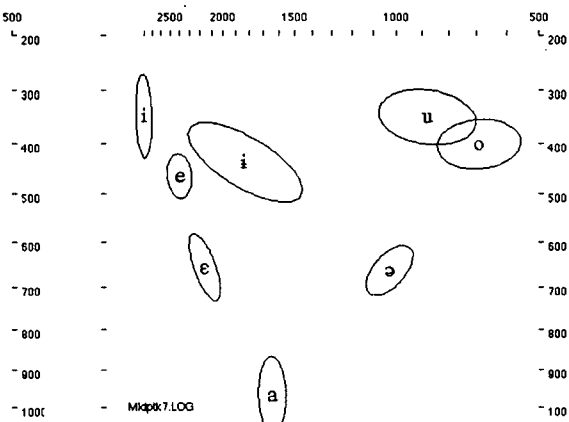


Figure 24. Seoul Dialect Speaker 8

3.2.3 Dynamic formant plots of five Seoul dialect speakers and five Kyongsang dialect speakers

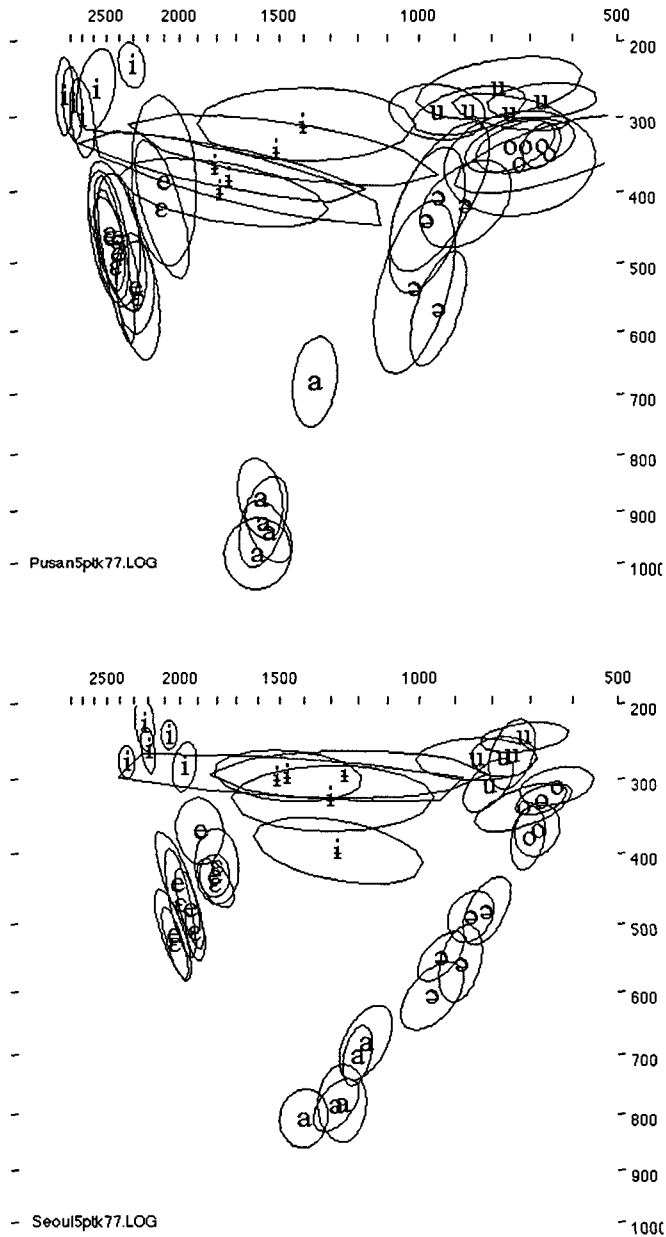


Figure 25. Dynamic formant plots of Korean Vowels of 5 Kyongsang Dialect Speakers (top) and 5 Seoul Dialect Speakers (bottom)

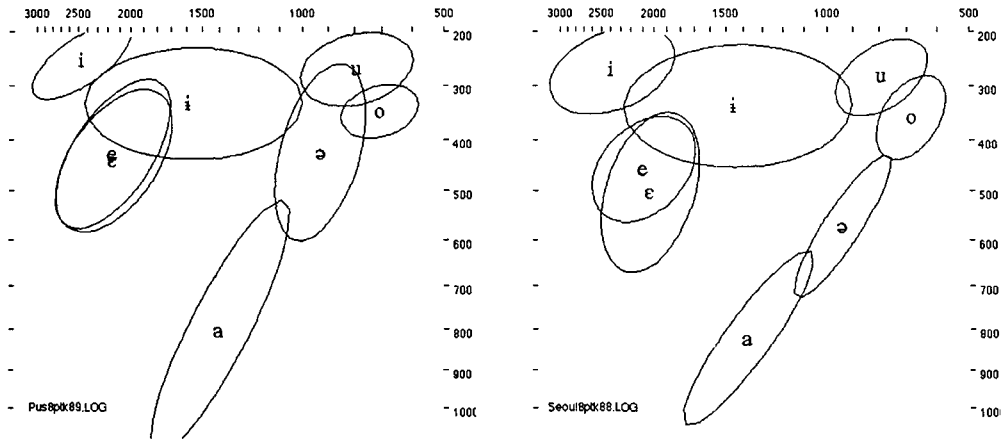


Figure 26. Combined formant plot of Korean vowels of 8 Kyongsang dialect speakers (left) and 8 Seoul dialect speakers (right) with 160 tokens for each vowel

Table 3. Means of F1/F2 of Each English Vowel of 6 American English Speakers (Hz)

	i		ɪ		e		ɛ		æ		ɜ		ə	
	F1	F2	F1	F2	F1	F2	F1	F2	F1	F2	F1	F2	F1	F2
AE 1	237	2259	353	1760	376	1979	512	1599	582	1702	367	1132	350	1553
AE 2	235	2203	365	1847	378	1964	520	1650	715	1623	328	1409	423	1549
AE 3	245	2183	409	1698	393	1933	527	1535	620	1471	403	1268	359	1452
AE 4	237	2582	405	2057	373	2361	641	1834	868	1728	407	1500	426	1766
AE 5	248	2208	380	1908	388	2042	542	1778	636	1650	434	1316	379	1674
AE 6	222	2305	386	1845	378	1971	526	1635	596	1687	384	1408	408	1411
Mean	237	2290	383	1852	381	2041	545	1672	669	1644	388	1335	389	1572

	ʌ		u		ʊ		o		ɔ		ɑ	
	F1	F2	F1	F2	F1	F2	F1	F2	F1	F2	F1	F2
AE1	487	1080	252	918	373	909	371	836	503	903	730	1305
AE2	487	1231	270	1058	371	881	412	968	540	985	549	936
AE3	548	1242	289	1059	388	984	439	979	595	1077	569	1016
AE4	631	1426	293	1191	403	1034	414	1134	639	1110	615	1058
AE5	540	1184	306	982	438	1009	462	1065	477	825	656	1195
AE6	492	1130	280	1078	416	957	426	980	514	931	638	1188
Mean	531	1215	282	1043	399	960	420	993	544	970	630	1124

Table 4. Means of F1/F2 of Each Korean Vowel of Kyongsang Dialect Speakers (Hz)

	i		e		ɛ		ɪ		ə		a		u		o	
	F1	F2	F1	F2	F1	F2	F1	F2	F1	F2	F1	F2	F1	F2	F1	F2
Busan1	263	2581	536	2288	550	2271	382	1737	440	980	938	1552	279	673	350	655
Busan2	231	2312	386	2101	424	2112	309	1408	407	944	679	1360	261	782	339	714
Busan3	282	2781	463	2484	456	2479	401	1784	536	1018	980	1604	291	859	362	729
Busan4	301	2697	463	2421	468	2417	366	1812	418	869	877	1589	293	948	339	753
Busan5	272	2853	487	2424	505	2426	344	1521	567	946	920	1576	307	762	331	679
Busan6	222	2138	343	1752	372	1734	314	1248	344	1002	549	1104	216	758	356	736
Busan7	247	2267	379	2061	395	2049	269	1813	355	824	735	1256	252	772	338	693
Busan8	218	2254	384	1911	403	1913	279	1359	382	910	773	1285	260	839	361	704
Mean	253	2482	428	2173	442	2165	333	1590	427	932	804	1410	269	795	347	710

Table 5. Means of F1/F2 of Each Korean Vowel of Seoul Dialect Speakers (Hz)

	i		e		ɛ		ɪ		ə		a		u		o	
	F1	F2	F1	F2	F1	F2	F1	F2	F1	F2	F1	F2	F1	F2	F1	F2
Seoul1	241	2071	431	1815	442	1809	295	1477	489	857	701	1206	244	719	309	640
Seoul2	260	2207	441	2023	470	2006	297	1519	548	942	807	1408	273	842	338	721
Seoul3	277	2355	515	2051	528	2038	396	1282	607	966	784	1283	308	810	380	709
Seoul4	226	2228	477	1952	511	1921	326	1305	558	886	781	1260	267	749	368	687
Seoul5	283	1981	369	1895	418	1803	293	1254	481	814	680	1178	270	771	328	677
Seoul6	240	2791	454	2394	481	2375	305	1497	670	1113	899	1568	260	782	343	681
Seoul7	280	2771	518	2360	530	2310	338	1511	625	1010	959	1577	299	839	408	743
Seoul8	348	2806	465	2403	656	2160	438	1845	663	1033	968	1645	350	882	402	694
Mean	271	2414	458	2109	504	2052	337	1467	573	945	824	1392	283	794	358	690

4. Conclusion

All six American English speakers had similar articulatory positions for the front vowels. They made the distinctions for /i/-/ɪ/, /e/-/ɛ/, and /ɛ/-/æ/ with partial overlaps. The /ɪ/ and /e/ were quite close or partly overlapped which is not surprising to English learners' ears in Korea. For the back vowels all of them had distinct articulatory positions for /u/-/ʊ/ and /o/-/ɔ/. But /ʊ/ and /o/ were considerably overlapped. For /ɔ/ and /a/, three American speakers made distinctions, but the other three speakers did not. The central vowels /ɜ/, /ə/ and /ʌ/ were all centrally positioned and their distributions were quite consistent.

Among three Korean front vowels /i/, /e/, and /ɛ/, the high front vowel /i/ was

separated from the other two, but /e/ and /ɛ/ overlapped in all fifteen speakers except one seoul speaker who had a special training in her phonetics class to make distinction between them. But the possibility cannot be ruled out that /e/-/ɛ/ distinction might exist psychologically in Korean speakers' mind because in transcribing English words into Korean, English /ɛ/ as in *pen* is always transcribed as /e/ as in 'pen' (펜), but English /æ/ as in *pan* is always transcribed as /ɛ/ as in 'pen' (펜). The position of the back vowels /u/ and /o/ matched the traditional Korean vowel positions. The central vowels /i/ and /a/ had clear high central and low central positions. The /ə/ had a back vowel position across speakers and dialects with their F1 and F2 ranging 344-670 and 814-1113, while American English /ə/ tended to converge on the neutral tongue position.

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