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An Experimental Study on the English Vowel Lengths Using the Praat Software Program

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Abstract

The purpose of this experimental study is to investigate and compare the vowel lengths of the English diphthongs, /eɪ/ and /aɪ/, and the front low vowel /æ/ among English-speaking natives with Korean college students using the Praat software program. To do this English sentences were uttered and recorded by twelve subjects, six Korean subjects and six English-speaking native subjects. All the subjects are female and their age ranges from 23 to 35. Acoustic features(duration) were measured from a sound spectrogram with the help of the Praat software program and analyzed through statistical analysis. Results showed that the vowel lengths of the English diphthongs and the front low vowel between native English speakers and Korean collegians were different. In the pronunciation of the diphthongs /eɪ/ and /aɪ/, Korean subjects pronounced longer than native subjects did, but the difference was not significant. However, in the pronunciation of the English front low vowel /æ/, native subjects pronounced significantly longer than Korean subjects did. From the data of the overall sum of words and vowels between the two subject groups, we were able to find out that the differences of lengths of both the three words and the two diphthongs /eɪ/ and /aɪ/ were not significant, but those of / æ / were significant.

Keywords : Praat software program, vowel lengths, low vowel, diphthong

Praat소프트웨어 프로그램을 이용한 영어모음 길이에 관한 실험적 연구

박희석*

요 약

본 연구는 Praat 소프트웨어 프로그램을 이용하여 영어이중모음 /eɪ/ 와 /aɪ/, 그리고 영어전설저모음 /æ/의 발음 길이에 관해 한국인 피 실험자와 원어민 피 실험자를 대상으로 그 차이를 비교분석해보고자 한 연구이다. 이 연구를 위해서 영어문장이 발화되고 녹음되었으며, 피 실험자는 한국인과 원어민 각각 6명씩 참가하였으며, 모두 여성이었고 나이는 23세에서 35세에 위치하고 있다. 음향특질중 하나인 길이측정을 위해서 Praat소프트웨어 프로그램을 활용하였으며, 그 결과를 통계 처리하였다. 실험결과 /eɪ/와 /aɪ/에서는 한국인들이 더 길게 발음하였지만 그 차이가 통계상 유의미한 수준은 아니었다. 그러나 /æ/의 발음에서는 한국인들의 발음 길이가 원어민에 비해 훨씬 짧았으며, 그 차이도 통계상 유의미한 수준으로 나타났다.

1. Introduction

This study was done to investigate the lengths of the English diphthongs, /eɪ/ and /aɪ/, and the front low vowel /æ/ between English-speaking natives and Korean college students through experiment, the result of which could be used in teaching English pronunciation in the classroom. I have already experimented with Koreans' foreign accent of

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the English diphthongs and the front low vowel using words and sentences made to be used in the experiment [1].

However, this study was experimented using

English conversation dialogue in *World English*, which is being used at Namseoul University as a textbook for freshmen. According to Park [2], in the pronunciation of the English front low vowel /æ/, Korean collegians showed a foreign accent especially in vowel length, which means that the English front low vowel lengths of Korean subjects were greater than those of native subjects significantly.

In this study, however, I experimented using English sentences written in the English conversation textbook, and Korean subjects were from Seoul and Gyeonggido province whose population use standard Korean. Today, in hearing students speaking English in the classroom, I think much of Korean students' English pronunciation is being improved due to the increased chance of talking with English native speakers and participating in exchange programs abroad. Instead of using this kind of subjective opinion, I will try to investigate the improvement of Korean students' pronunciation features based on the results of the experiment of this study, which could be considered objective judgment. Especially, I plan to investigate the lengths of Korean students' pronunciation of the English front low vowel /æ/, which showed a foreign accent according to Park [2]. In addition to this, the lengths of Korean students' pronunciation of the English diphthongs /eɪ/ and /aɪ/ will be investigated. To do this, I selected English test sentences from the page 137 of *World English*, which is being used as a textbook for Namseoul University freshmen. The three words used in the experiment are vacation, buy, and camera, which include two English diphthongs /eɪ/ and /aɪ/ and front low vowel /æ/ respectively in the stressed syllable. English-speaking native and Korean subjects were asked to pronounce the dialogue like everyday English. However, they were not instructed as to which parts were being tested. The sound data was measured by Praat and the data was analyzed statistically to find out if the differences are significant between the two groups of subjects. To see if there is any difference in the pronunciation of students who participated in exchange programs abroad and took English phonetics in their college life, I selected subjects from English Department senior students of Namseoul University, who already had that experience.

2. Literature Review

There have been some studies related to English vowel lengths. Crystal & House showed that stressed vowels are longer than unstressed vowels [3]. According to them, in the case of the diphthong /aɪ/, the lengths of stressed are 173 ms whereas those of unstressed are 114 ms. In the case of the English diphthong /eɪ/, they described it as /e/, where the lengths of stressed are 136 ms and those of unstressed are 78 ms. In the case of the English front low vowel /æ/, still according to them, the lengths of stressed are 159 ms whereas those of unstressed are 71 ms. Harriet & Blumstein investigated the effect of speaking rate on vowel duration in Korean [4]. With the results of the study, they said that the long and short members of the vowel length contrast were similarly affected across speaking rates. According to their study, the durations of short vowels spoken at a slow rate were always longer than short vowels spoken at a fast rate, and that short vowels spoken at a slow rate almost always overlapped in duration with long vowels spoken at a fast rate. They also explained

that their study showed that the distinction between short and long vowels emerged less consistently in sentential context than in isolation. They concluded that using the data the vowel length distinction is being lost in Korean and is no longer a productive contrast. Dennis H. Klatt tried to find out factors that influence vowel duration [5]. According to the study, stressed vowels are shorter before voiceless consonants than before voiced. In addition to that, the study argued that stressed vowels are shorter before an unstressed syllable in a bisyllabic word than in a monosyllabic word. Dennis H. Klatt tried to find out the changes of vowel lengths and showed—using the data— that stressed vowels in word-final syllables of phrase-final words were significantly longer in duration than vowels in any other position [6]. According to the study, vowels in phrase-final syllables are 40 ms longer on the average than in other positions. D. Kimbrough Oller also argued in his study that final syllables were found to be longer than nonfinal syllables [7]. He showed that final-syllable lengthening occurs in word-final and phrase-final positions as well as in utterance-final position. There also have been studies related to vowel lengths conducted by Koreans. Kong-On Kim did a pioneer research in this field [8]. In his comparative study of vowel lengths in relation to their utterance positions using a set of nonsense words, he showed that syllables in sentence-final position were significantly longer in duration than syllables in any other position. He also showed that syllables in sentence-initial position were slightly longer in duration than syllables in other positions except sentence-final position. Do-Heung Ko tried to find out the duration changes of Korean long and short vowels in isolation and context position using the spectrograph [9]. Park tried to find out the difference in the foreign accent of vowel lengths between Korean and native subjects [10].

3. Method

3.1 Subjects

12 females were chosen to participate in this experiment, acting as subjects: 6 Korean female students from Namseoul University and 6 English-speaking female natives from Suwon Global Village. The six Namseoul University students have the experience of having studied abroad for more than six months in the U.S. and Canada. As they are English major senior students, they already have taken English phonetics in their college life. Their ages range from 23 to 26 and have grown up in Gyeonggido and Seoul, where people speak the standard Korean language. The native speakers of English are from the U.S and Canada, and they are teaching Korean elementary school students at Suwon Global Village. Their ages range from 28 to 35 and they are thought to speak General American English. According to Yang [11], as speaker variation has been attributed to (1) linguistic factors such as dialectal and sociolectal differences and (2) non-linguistic factors such as physical anatomy, age, gender, and emotional state of the speaker, I have tried to exclude such factors as could bring bad effects on the results of the experiment of this study.

3.2 Material

For this experiment, conversation dialogues in *World English* page 137 were used, which is now being used as the everyday conversation textbook for Namseoul University freshmen. As the class is required for all the students, they were familiar with the textbook. The main reason I selected this book was that in this dialogue I could find the three words, vacation, buy, and camera. These three words

have two English diphthongs, /eɪ/ and /aɪ/, and an English front low vowel /æ/ respectively, all of which are apt to be pronounced differently by Koreans and English-speaking natives especially in vowel lengths. In addition to that, the three words are repeated four times in the dialogue and it is easy to compare among the words and vowels. Followings are the scripts used as experimental material.

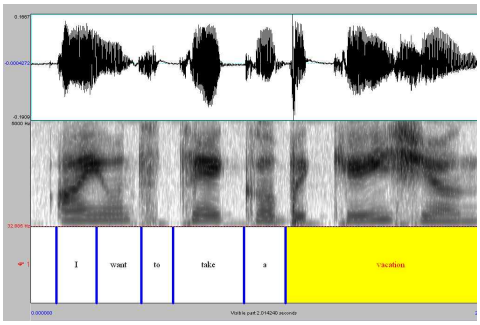
Jim: I want to take a vacation (1-1) and I also want to buy (2-1) a new camera (3-1).
Dave: I see. If you buy (2-2) the camera (3-2), you won't have enough money for the vacation (1-2). Is that it?
Jim: You got it.
Dave: So, just take the vacation (1-3). Don't buy (2-3) the camera (3-3).
Jim: But if I don't buy (2-4) the camera (3-4), I won't be able to take any vacation (1-4) photos.

3.3 Procedures

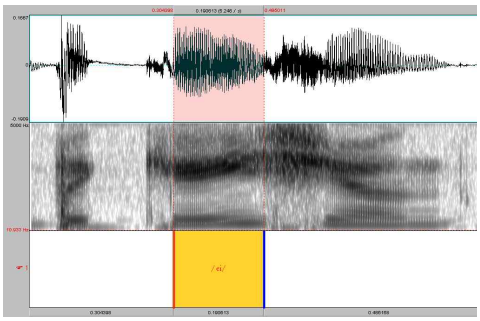
The twelve subjects were asked to read the dialogues as if they were talking in everyday conversation. In reading each team consisted of two subjects who were asked to read the dialogues alternately. When they read the dialogues, they were unaware of the purpose of reading. After mp3 recordings were made in an office room, the sound data were sent to my computer as an mp3 file. With the help of the Praat software program, I measured the lengths of words and vowels. As the three words, vacation, buy, and camera, have /eɪ/, /aɪ/, and /æ/ respectively in their stressed syllable, I could measure both the vowel lengths of /eɪ/, /aɪ/, and /æ/ and the three words simultaneously. After measuring the lengths, I analyzed the data statistically and tried to find out the difference of vowel lengths and vowel ratio between the two subject groups.

3.4 Measuring the lengths

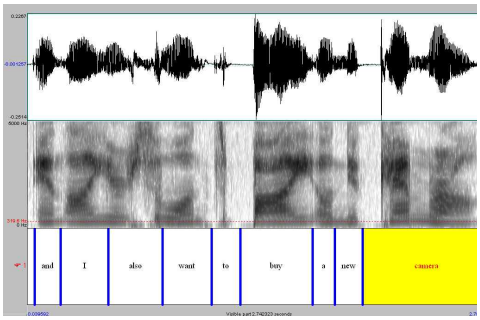
Using the software program, I measured the English words and vowels and the followings show the way of measuring the first sentence of Jim's. As we Koreans are apt to show foreign accent of /æ/, I tried to distinguish the front vowels /eɪ/ from /æ/ respectively in detail using spectrogram.



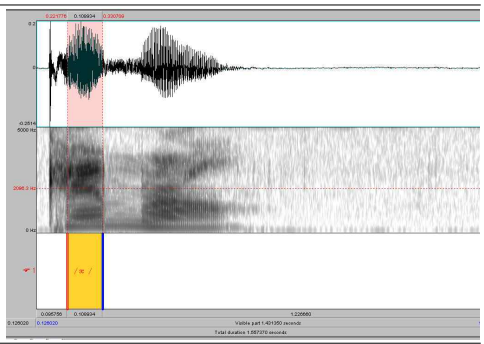
<Figure. 1> spectrogram of the sentence of a native subject



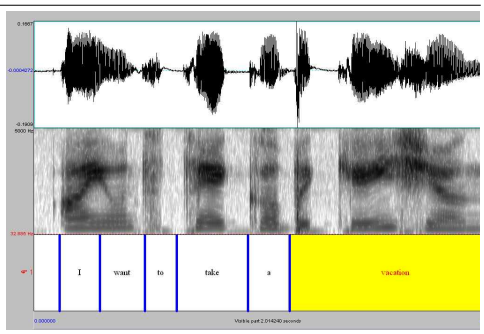
<Figure. 2> spectrogram of /ei/ of a native subject



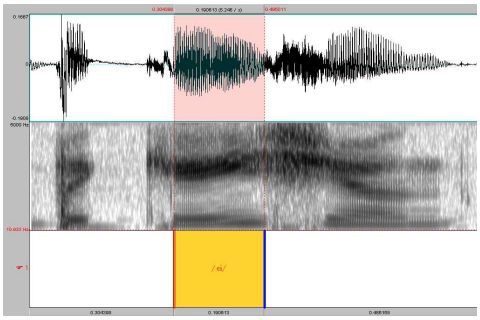
<Figure. 3> spectrogram of the sentence of a native subject



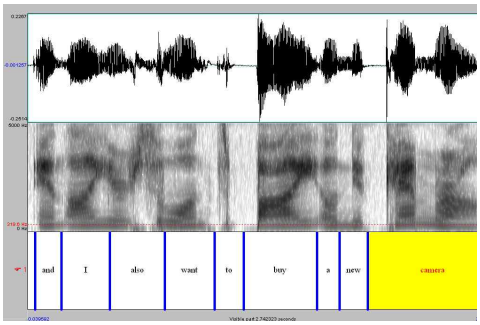
<Figure. 4> spectrogram of /æ/ of a native subject



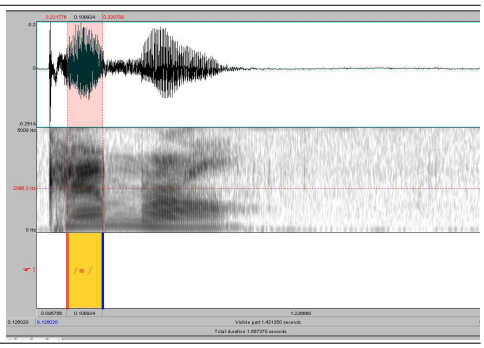
<Figure. 5> spectrogram of the sentence of a Korean subject



<Figure. 6> spectrogram of /ei/ of a Korean subject



<Figure. 7> spectrogram of the sentence of a Korean subject



<Figure. 8> spectrogram of /æ/ of a Korean subject

4. Results and Discussion

4.1 Comparison of English Word 'Vacation' and Diphthong /eɪ/ between

Two Groups

From <TABLE 1> to <TABLE 4>, we can see the difference of lengths of the word 'vacation' and the diphthong /eɪ/ between the two subject groups. From the tables, we can recognize that, in the diphthong /eɪ/, there is no significant difference of vowel lengths between the two subject groups. Though Park [10] showed a foreign accent of the diphthong /eɪ/, this Korean subject group doesn't show any significant difference in vowel lengths. From the fact that the Korean subjects have participated in exchange student programs more than six months and already took English phonetics class, I could imagine that, through proper pronunciation drill and exposure to an English-speaking culture, Korean students possibly improve the pronunciation of the English diphthong /eɪ/ at least in vowel lengths. However, according to <TABLE 13>, we can find some critical contrast in Korean subjects' pronunciation between the word 'vacation' and the diphthong /eɪ/; while Korean subjects pronounce the word shorter than English-speaking native subjects do, they pronounce the diphthong /eɪ/ longer than English-speaking native subjects do, which means that Korean subjects pronounce the diphthong /eɪ/ longer than English-speaking native subjects though the difference is not significant. I think that in teaching Korean students English pronunciation, we should be able to use this information. According to <TABLE 2>, the sentence lengths of Korean subjects are significantly larger than those of English-speaking native subjects, which suggests that Korean subjects have difficulty in speaking English rhythm. English is said to have a stressed-timed rhythm, and Korean syllable-timed rhythm. In addition to this, the sentences, in <TABLE 2> and <TABLE 4>, consist of an adverbial clause and a main clause, and it is not easy for Korean subjects to follow English rhythm in complex sentences, which might result in the difference of duration in sentence lengths. According to the tables from 1 to 4, there is no significant difference in the lengths of the word 'vacation' except 4, which showed a significant length difference in the word 'vacation', and the reason for this result could be treated further next time.

<TABLE 1> Comparison of vacation (1) placed in sentence between two subject groups

(unit: ms)

Vacation (1)	subjects	mean	standard deviation	t-value
length of sentence	Koreans	3933.67	588.84	.279 NS
	natives	3841.33	559.09	
length of word	Koreans	658.67	84.36	-1.101 NS
	natives	703	51.08	
length of vowel /eɪ/	Koreans	138.67	27.68	.721 NS
	natives	129.50	14.31	
vowel ratio (vowel/ word)	Koreans	20.97%	2.46	2.316 NS
	natives	18.40%	1.15	

<TABLE 2> Comparison of vacation (2) placed in sentence between two subject groups

(unit: ms)

Vacation (2)	subjects	mean	standard deviation	t-value
length of sentence	Koreans	4135.83	513.01	2.391*
	natives	3557.83	295.59	
length of word	Koreans	665.00	69.00	-.804 NS
	natives	697.00	68.93	
length of vowel /eɪ/	Koreans	121.17	19.14	-.697 NS
	natives	127.17	8.96	
vowel	Koreans	18.23%	2.32	-.159

ratio (vowel/ word)	natives	18.48%	3.07	NS

*p<.05

<TABLE 3> Comparison of vacation (3) placed in sentence between two subject groups

(unit: ms)

vacation (3)	subjects	mean	standard deviation	t-value
length of sentence	Koreans	1929.83	203.30	-.123 NS
	natives	1964.83	669.63	
length of word	Koreans	726.00	36.85	2.137 NS
	natives	671.00	51.17	
length of vowel /eɪ/	Koreans	135.17	27.40	.721 NS
	natives	125.00	21.05	
vowel ratio (vowel/ word)	Koreans	18.70%	3.98	.052 NS
	natives	18.60%	2.51	

<TABLE 4> Comparison of vacation (4) placed in sentence between subject groups

(unit: ms)

vacation (4)	subjects	mean	standard deviation	t-value
length of sentence	Koreans	5176.00	387.72	1.759 NS
	natives	4673.17	582.89	
length of word	Koreans	561.17	29.48	-2.734*
	natives	610.83	33.34	
length of vowel /eɪ/	Koreans	119.00	22.79	.807 NS
	natives	110.50	12.08	
vowel ratio (vowel/ word)	Koreans	21.17%	3.65	1.694 NS
	natives	18.15%	2.40	

*p<.05

4.2 Comparison of the English Word 'buy' and the Diphthong /aɪ/ between Two Groups

From <TABLE 5> to <TABLE 8>, we can see the difference of the lengths of the word 'buy' and the diphthong /aɪ/ between the two subject groups. According to the tables from 5 to 8, the lengths of the Korean subjects' diphthong /aɪ/ are bigger than the English-speaking natives', and the difference of the lengths of the diphthong /aɪ/ between the two subject groups is significant in buy (4), which is a different result from that of the diphthong /eɪ/. According to <TABLE 14>, overall lengths of the word 'buy' and the diphthong /aɪ/, the lengths of the Korean subjects' pronunciation are bigger than those of the English-speaking native subjects' though the difference is not significant. However, still according to <TABLE 14>, there is a significant difference of vowel ratio between the Korean subjects and the English-speaking native subjects, which could be interpreted as meaning that the lengths of the consonant /b/ of the Korean subjects are bigger than those of the English-speaking subjects.

<TABLE 5> Comparison of buy (1) placed in sentence between the two subject groups

(unit: ms)

buy (1)	subjects	mean	standard deviation	t-value
length of sentence	Koreans	3933.67	588.84	.279 NS
	natives	3841.33	559.09	
length of word	Koreans	243.17	42.96	.660 NS
	natives	222.17	64.97	
length of vowel /aɪ/	Koreans	207.33	44.76	.177 NS
	natives	201.83	61.37	
vowel ratio (vowel/ word)	Koreans	84.85%	4.79	-2.249 NS
	natives	90.62%	4.07	

<TABLE 6> Comparison of buy (2) placed in sentence between the two subject groups

(unit: ms)

buy (2)	subjects	mean	standard deviation	t-value
length of	Koreans	4135.83	513.01	2.391*

sentence	natives	3557.83	295.59	
length of word	Koreans	208.50	55.87	1.030 NS
	natives	180.83	34.77	
length of vowel /aɪ/	Koreans	176.67	45.58	.619 NS
	natives	162.83	30.39	
vowel ratio (vowel/ word)	Koreans	84.87%	3.76	-2.704*
	natives	90.18%	3.01	

*p<.05

<TABLE 7>Comparison of buy (3) placed in sentence between the two subject group (unit: ms)

buy (3)	subjects	mean	standard deviation	t-value
length of sentence	Koreans	1046.50	21.65	-.263 NS
	natives	1063.50	156.84	
length of word	Koreans	183.67	12.66	.688 NS
	natives	173.00	35.79	
length of vowel /aɪ/	Koreans	156.83	13.17	.107 NS
	natives	155.17	35.64	
vowel ratio (vowel/ word)	Koreans	85.37%	3.26	-2.471*
	natives	89.40%	2.31	

*p<.05

<TABLE 8> Comparison of buy (4) placed in sentence between the two subject groups (unit: ms)

buy (4)	subjects	mean	standard deviation	t-value
length of sentence	Koreans	5176.00	387.72	1.759 NS
	natives	4673.17	582.89	
length of word	Koreans	205.33	40.76	2.032 NS
	natives	165.50	25.37	
length of vowel /aɪ/	Koreans	185.50	32.98	2.659*
	natives	144.50	18.40	
vowel ratio (vowel/ word)	Koreans	90.70%	2.93	1.273 NS
	natives	87.70%	4.97	

4.3 Comparison of the English Word 'camera' and the Front Low Vowel /æ/ between the Two Groups

From <TABLE 9> to <TABLE 12>, we can see the difference of the lengths of the word 'camera' and the front low vowel /æ/ between the two subject groups. Through all the tables from 9 to 12, the striking point is that, in the pronunciation of the English front low vowel /æ/, there is a significant difference in the vowel lengths between the Korean subjects and the English-speaking native subjects. The results of these tables suggest a very critical point to Koreans. If we consider that the Korean subjects of this experiment have already participated in exchange programs abroad and taken English pronunciation class, the serious condition of the foreign accent of these vowel lengths looks even clearer. According to theses tables, there are also significant differences of vowel ratio between the Korean subjects and the English-speaking native subjects, which means that English-speaking native subjects pronounce the English front low vowel /æ/ significantly longer than the Korean subjects do. Even though, between the two groups, the native subjects pronounce the word 'camera' longer than the Korean subjects do, the difference is not of any significance. However, in the vowel ratio, there is a significant difference between two groups, which means that the big difference results from the pronunciation of the English front low vowel /æ/.

<TABLE 9> Comparison of camera (1) placed in sentence between the two subject groups

(unit: ms)

Camera (1)	subjects	mean	standard deviation	t-value
length of sentence	Koreans	3933.67	588.84	.279 NS
	natives	3841.33	559.09	
length of word	Koreans	423.33	60.28	-.865 NS
	natives	465.17	102.00	
length of vowel /æ/	Koreans	69.83	27.01	-3.765**
	natives	123.67	22.30	
vowel ratio (vowel/ word)	Koreans	16.53%	6.37	-3.315**
	natives	27.07%	4.48	

** $p<.01$

<Table 10> Comparison of camera (2) placed in sentence between the two subject groups

(unit: ms)

Camera (2)	subjects	mean	standard deviation	t-value
length of sentence	Koreans	4135.83	513.01	2.391*
	natives	3557.83	295.59	
length of word	Koreans	486.17	30.49	-.550 NS
	natives	501.33	60.33	
length of vowel /æ/	Koreans	72.83	14.47	-6.825***
	natives	119.00	8.08	
vowel ratio (vowel/ word)	Koreans	14.88%	2.23	-5.649***
	natives	24.02%	3.27	

*$p<.05$***$p<.001$

<Table 11> Comparison of camera (3) placed in sentence between the two subject groups

(unit: ms)

Camera (3)	subjects	mean	standard deviation	t-value
length of sentence	Koreans	1046.50	21.65	-.263 NS
	natives	1063.50	156.84	
length of word	Koreans	423.33	35.97	-.883 NS
	natives	444.67	47.04	
length of vowel /æ/	Koreans	71.00	21.74	-3.764**
	natives	121.50	24.66	
vowel ratio (vowel/ word)	Koreans	16.85%	5.44	-3.309**
	natives	27.37%	5.57	

** $p<.01$

<Table 12> Comparison of camera (4) placed in sentence between the two subject groups

(unit: ms)

Camera (4)	subjects	mean	standard deviation	t-value
length of sentence	Koreans	5176.00	387.72	1.759 NS
	natives	4673.17	582.89	
length of word	Koreans	489.83	53.06	-.062 NS
	natives	491.83	59.32	
length of vowel /æ/	Koreans	82.83	31.07	-2.743*
	natives	121.50	15.07	
vowel ratio (vowel/word)	Koreans	16.93%	5.69	-2.974*
	natives	24.88%	3.24	

*$p<.05$

4.4 Comparison of overall sum of three words and vowels in sentence between the two subject groups

From <TABLE 13> to <TABLE 15>, we can see the statistical analysis of the experiment data on vacation, buy, and camera. This data consist of the overall sum of every feature of each word pronounced four times by the two subject groups. These tables show that, in the case of both the words 'vacation', 'buy', and 'camera' and the diphthongs /eɪ/ and /aɪ/, there aren't any significant differences in the vowel lengths between the two subject groups. However, in the case of the English front low vowel /æ/, there is a

significant difference in the vowel lengths between the two subject groups; the vowel lengths of the Korean subjects are much smaller than those of the English-speaking native subjects. Though, in the case of the two diphthongs /eɪ/ and /aɪ/, the vowel lengths of the Korean subjects are bigger than those of the English-speaking native subjects, the differences are not significant. Now we can see the difference of word, vowel lengths, and vowel ratio following each word. In the case of vacation, according to <TABLE 13>, the lengths of the word 'vacation' of the Korean subjects are smaller than those of the English-speaking native subjects, whereas the diphthong /eɪ/ lengths and the vowel ratio of the Korean subjects are bigger than those of the English-speaking native subjects, but those differences are not significant. In the case of buy, according to <TABLE 14>, the word 'buy' and diphthong /aɪ/ lengths of Korean subjects are bigger than those of English-speaking native subjects, whereas the vowel ratio of the Korean subjects are smaller than that of the English-speaking native subjects, and that difference is significant. In the case of camera, according to <TABLE 15>, there are significant differences of vowel ratio between the Korean subjects and the English-speaking native subjects, which means that the English-speaking native subjects pronounce the English front low vowel /æ/ significantly longer than the Korean subjects do. Even though the English native subjects pronounce the word 'camera' longer than the Korean subjects do, the difference is not of any significance. However, there is a significant difference of vowel ratio between the two groups, which means that the big difference results from the pronunciation of the English front low vowel /æ/. Also the vowel ratio of the Korean subjects is bigger than that of the English-speaking native subjects, and those differences are significant.

<Table 13> Comparison of the overall sum of vacation between the two subject groups

(unit: ms)

Vacation (1)~(4)	subjects	mean	standard deviation	t-value
length of sentence	Koreans	3793.83	1270.68	.822 NS
	natives	3509.29	1123.97	
length of word	Koreans	652.71	81.87	-.849 NS
	natives	670.46	61.63	
length of vowel /eɪ/	Koreans	128.50	24.46	.920 NS
	natives	123.04	15.72	
vowel ratio (vowel/ word)	Koreans	19.77%	3.26	1.685 NS
	natives	18.41%	2.23	

<Table 14> Comparison of the overall sum of buy between the two subject groups

(unit: ms)

buy (1)~(4)	subjects	mean	standard deviation	t-value
length of sentence	Koreans	3573.00	1617.86	.655 NS
	natives	3283.96	1434.02	
length of word	Koreans	210.17	44.16	1.908 NS
	natives	185.38	45.83	
length of vowel /aɪ/	Koreans	181.58	38.79	1.309 NS
	natives	166.08	43.11	
vowel ratio (vowel/ word)	Koreans	86.45%	4.31	-2.624*
	natives	89.48%	3.66	

*p<.05

<Table 15> Comparison of the overall sum of camera between the two subject groups

(unit: ms)

Camera (1)~(4)	subjects	mean	standard deviation	t-value
length of sentence	Koreans	3573.00	1617.86	.655 NS
	natives	3283.96	1434.02	
length of word	Koreans	455.67	54.57	-1.114 NS
	natives	475.75	69.41	

length of vowel /æ/	Koreans	74.13	23.33	-7.942***
	natives	121.42	17.51	
vowel ratio (vowel/ word)	Koreans	16.30%	4.91	-7.214***
	natives	25.83%	4.22	

*** $p<.001$ * $p<.05$

5. Conclusion

Through statistic analysis of the experimental data, I found out the following: Firstly, we recognize that, in the diphthong /eɪ/, there is no significant difference of vowel lengths between the two subject groups, which could be one of the most important points in the data. Though the diphthong /eɪ/ is prone to show foreign accent in Korean speakers [10], this Korean subject group doesn't show any significant difference in vowel lengths. However, according to <TABLE 13>, we can find some critical contrast in the pronunciation of the Korean subjects between the word 'vacation' and the diphthong /eɪ/; while the Korean subjects pronounce the word shorter than the English-speaking native subjects do, they pronounce the diphthong /eɪ/ longer than the English-speaking native subjects do, which means the Korean subjects pronounce the diphthong /eɪ/ longer than the English-speaking native subjects do though the difference is not significant.

Secondly, we can see the difference of the lengths of the word 'buy' and the diphthong /aɪ/ between the two subject groups. According to the tables from 5 to 8, the lengths of the Korean subjects' diphthong /aɪ/ are bigger than the English-speaking natives', and the difference of the lengths of the diphthong /aɪ/ between the two subject groups is significant in buy (4). According to <TABLE 14>, the overall lengths of the word 'buy' and the diphthong /aɪ/, the lengths of the Korean subjects' pronunciation are bigger than those of the English-speaking native subjects' though the difference is not significant. However, still according to <TABLE 14>, there is a significant difference of the vowel ratio between the Korean subjects and the English-speaking native subjects, which could be interpreted that the lengths of the consonant /b/ of Korean subjects are bigger than those of English-speaking subjects.

Thirdly, from <TABLE 9> to <TABLE 12>, we can see the difference of the lengths of the word 'camera' and the front low vowel /æ/ between the two subject groups. Through all the tables from 9 to 12, the striking point is that, in the pronunciation of the English front low vowel /æ/, there is a significant difference in the vowel lengths between the Korean subjects and the English-speaking native subjects. According to these tables, there are also significant differences of vowel ratio between the Korean subjects and the English-speaking native subjects, which means that English-speaking native subjects pronounce the English front low vowel /æ/ significantly longer than the Korean subjects do. Even though the English native subjects pronounce the word 'camera' longer than the Korean subjects do, the difference is not of any significance. However, there is a significant difference of vowel ratio between the two groups, which means that the big difference results from the pronunciation of the English front low vowel /æ/.

Fourthly, from <TABLE 13> to <TABLE 15>, whose data consist of the overall sum of every feature of each word pronounced four times by the two subject groups, we can see that, in the case of both the words 'vacation', 'buy', and 'camera' and the diphthongs /eɪ/ and /aɪ/, there aren't any significant difference of vowel lengths between the two subject groups. However, in the case

of the English front low vowel /æ/, there is a significant difference of vowel lengths between the two subject groups; the vowel lengths of the Korean subjects are much smaller than those of English-speaking native subjects. Now we can see the difference of word, vowel lengths, and vowel ratio following each word. In the case of vacation, according to <TABLE 13>, the word 'vacation' lengths of Korean subjects are smaller than those of the English-speaking native subjects, whereas the diphthong /eɪ/ lengths and vowel ratio of Korean subjects are bigger than those of the English-speaking native subjects, but those differences are not significant. In the case of buy, according to <TABLE 14>, the word 'buy' and the diphthong /aɪ/ lengths of the Korean subjects are bigger than those of the English-speaking native subjects, whereas the vowel ratio of the Korean subjects are smaller than that of the English-speaking native subjects, and that difference is significant. In the case of camera, according to <TABLE 15>, there are significant differences of the vowel ratio between the Korean subjects and the English-speaking native subjects, which means that the English-speaking native subjects pronounce the English front low vowel /æ/ significantly longer than the Korean subjects do.

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