



## Effects of Word Stress on Vowel Duration and Vowel Quality in the Speech of Korean Learners of English

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모음길이/  
모음특성

### ABSTRACT

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Unstressed English vowels are reduced in their durational and spectral aspects. Vowel reduction in relation to word stress in English has been one of the challenges faced by Korean learners of English in learning English vowel system. In this study, we investigated effects of word stress on the vowel duration and vowel quality. This study focused on two unstressed vowels (/ə/ and /ɪ/) and three stressed vowels (/ʌ/, /ɪ/, and /i/). Words with five target vowels in the first syllable of word were collected from sentences produced by two subject groups. Vowel durations and first and second formant values were calculated and analyzed for the effect of stress which interplayed with intrinsic vowel duration and vowel quality. Study results indicated that speech data of Korean learners of English had much less magnitude in vowel shortening and reduction of vowel quality in unstressed vowels than those of English speakers. In addition, the five target vowels tended to be grouped into two in vowel space for Korean learners of English. Pedagogical implications of this study are discussed to improve learning and teaching English vowel system for Korean learners of English.

### I. INTRODUCTION

Word stress in English can be signaled by syllable duration, pitch, and loudness. They are prosodic cues. Other than these prosodic cues, native English listeners use a segmental cue, such as vowel quality to perceive word stress. If the vowel has its full quality, it is perceived as stressed. If the vowel has reduced quality, it is not perceived as stressed (Cutler, 2015). The vowel quality of one vowel is distinguished from another by the differences of the formant structures. The first formant (F1) is inversely related to vowel height in vowel space. The second formant (F2)

is related to the degree of backness of a vowel in vowel space (Ladefoged, 2006).

As the Korean language does not have word stress, Korean learners of English are expected to find it difficult to produce the durational and vowel quality changes in vowels in relation to stress placement.

In this study we investigate the phonetic effect of stress on English vowels. Stress can occur in any syllable in an English word. We focus on the vowels in the first syllable of a word. When stress is put on the first syllable, the vowel will retain its full vowel form. However, when stress is on the second syllable of a word, the unstressed vowel of

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the first syllable will not retain its full form.

The unstressed vowels in the first syllable of words will be compared with the stressed vowels in the first syllable of words. The vowel duration and the vowel first formant and second formant frequency values will be measured to examine the durational and vowel space characteristics of unstressed vowels /ə/ and /ɪ/ in comparison to stressed vowels /ʌ/, /ɪ/, and /i/ in the native and nonnative subject groups. The pedagogical implication of the results of this study will be discussed based on the duration and vowel space characteristics of nonnative English vowels produced by Korean learners of English.

## II. RESEARCH BACKGROUND

English is a lexical stress language. The syllables of an English word will differ in their relative phonetic prominence. This type of differences across syllables distinguishes stress languages from languages that do not have stress in their phonology (Cutler, 2015; Dauer, 1983; Grabe & Low, 2002). Many studies have found that the distinction between unreduced vowels and reduced vowels is the most reliable cue to English word stress (Cooper et al., 2002; Cutler 1986, 2015; Cutler & Clifton, 1984).

According to Fry (1955), unstressed vowels of English are reduced, which means lower in pitch, shorter in duration, less loud in intensity, and rather reduced in vowel quality. Vowels in unstressed syllables or vowels in function words tend to be reduced because they lack stress (Umeda, 1975). Reduced vowels are more central than stressed ones in vowel space (Ladefoged, 2006).

Klatt (1976) states that it seems likely that an important perceptual correlate of an unstressed or reduced vowel is a reduction in its duration. However, the study on foreign-accented English unstressed vowels by Braun et al. (2011) suggests that vowel quality is more important cue to word stress than duration or intensity. Ghosh and Lewis (2021) provides evidence that shows segmental cues are more important to L1 English listeners in how words are identified in speech. Their study results indicate that English word stress errors affect intelligibility most when stress errors introduce concomitant vowel errors.

In this study, we investigate the duration and vowel space of the unstressed vowels /ə/ and /ɪ/ in comparison with their stressed vowel counterparts /ʌ/, /ɪ/, and /i/. The study focus is on the phonetic characteristics of English vowels in the speech of Korean learners of English. The Korean language differs from English in vowel inventory. In English, tense vowels and lax vowels such as /i/ and /ɪ/ are different phonemes (H. B. Lee, 2004). But Korean does not have the different vowels corresponding to English tense vowel /i/ and lax vowel /ɪ/. The Korean language doesn't have word stress and its vowel durational pattern is less variable than that of English. We expect that the vowels produced by Korean learners of English might have their own durational and formant structure characteristics which differ from those of native English speakers,

partly due to transfer of the phonological characteristics of the native Korean language. English word stress and the relevant vowel duration and vowel space characteristics are critical for the intelligibility of L2 speech (Deterding, 2013; Lewis & Deterding, 2018). The study results of this study are expected to have implications for effective teaching and learning of L2 English pronunciation.

## III. RESEARCH METHOD

### 1. Materials and Participants

The speech materials are words with stress on the second syllable and words with stress on the first syllable. The target vowels are unstressed vowels /ə/ and /ɪ/ of the first syllable in words such as 'attention' and 'investors', and stressed vowels /ʌ/, /ɪ/, and /i/ of the first syllable in words such as 'muffins', 'sisters', and 'teachers.' We included the words with varying number of syllables in this study based on the study result of Harris and Umeda (1974). They showed that the number of syllables is a negligible factor regarding vowel duration in connected speech.

Target words were presented on the computer screen in sentence context and the participants read the sentences including target words at the speed of normal speech. Seven words for each of the five target vowels were collected, and a total number of 420 words (5 vowels × 7 words × 12 speakers) were segmented and analyzed. The material words for the production experiment are listed in Table 1.

**TABLE 1**  
Material Words in the Production Experiment

Unstressed /ə/	Attracted	Appeal
	Attention	Computers
	Adults	Oppose
	Advanced	
Unstressed /ɪ/	Excited	Degrees
	Improvement	Important
	Investors	Detectives
	Divisions	
Stressed /ʌ/	Buses	Muffins
	Tubs	Nuts
	Companies	Bustled
	Comfortable	
Stressed /ɪ/	Sisters	Big
	Syndrome	Injuries
	Kids	Mixed
	Hidden	
Stressed /i/	Diesel	Beaches
	Evenings	Keyboards
	Teens	Teachers
	Featured	

The participants of the production experiment were six native speakers of American English (one male speaker and five female speakers) and six Korean learners of English (one male speaker and five female speakers). They were all university undergraduates in their twenties.

## 2. Measurements and Analysis

Using the Praat (Boersma & Weenink, 2013) software, target vowel intervals of all the material words were segmented and labelled manually by the author. Vowel intervals were taken from vowel onset to vowel offset. Vowel formants and regularity of the waveform were used as criteria for the onset and the offset of the target vowels. Vowel durations and frequencies of the first and second formants were calculated using Praat script. The example of segmentation and labelling is shown in Figure 1. The upper panel shows an example of a vowel in the unstressed first syllable, and the lower panel shows an example of a vowel in the stressed first syllable. Paired sample *t*-tests were conducted testing the effect of stress on target vowel duration and formant frequency values. Critical significance was set at  $p < .05$ .

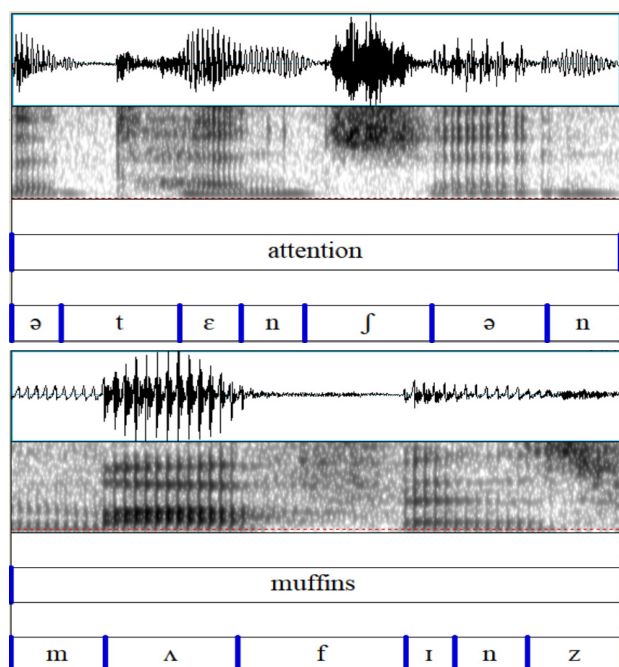


FIGURE 1 Sound Waves and Spectrograms with Labelled Vowel Intervals

## IV. RESULTS AND DISCUSSION

### 1. Effect of Stress on Vowel Duration in the Speech of Native English Speakers

Vowel reduction in relation to stress was examined by measuring duration of unstressed and stressed vowels which are in the first syllable of the material words. Vowels occurring in unstressed syllables of English words are /ə/ or /ɪ/ that have a reduced vowel quality. Unlike unstressed vowel /ə/,

unstressed vowel /ɪ/ preserves a full vowel quality. English vowel /ɪ/ can occur in both stressed and unstressed syllables. Table 2 shows the duration of the unstressed and stressed vowels produced by native English speakers. The vowel durations are averaged across six participants for each target vowel. As shown in the duration values, unstressed vowels are much shorter than the counterpart stressed vowels. The duration of /ə/ in the unstressed first syllable is 58ms. And the duration of /ʌ/ in the stressed first syllable is 87 ms. The duration difference is 29ms. The other two vowel pairs have more than 30ms differences between unstressed and stressed vowels. The duration differences in the three unstressed and stressed vowel pairs (unstressed /ə/ and stressed /ʌ/, unstressed /ɪ/ and stressed /ɪ/, unstressed /ɪ/ and stressed /i/) in Table 2 are statistically significant ( $t = -4.499, p = .000$ ;  $t = -4.630, p = .000$ ;  $t = 7.902, p = .000$  respectively).

TABLE 2

Vowel Durations and T-test Results in the Speech of Native English Speakers

		<i>n</i>	<i>M</i>	<i>SD</i>	<i>t</i>	<i>p</i>
	Unstressed /ə/	42	58	19	-4.499	.000
	Stressed /ʌ/	42	87	32		
Unstressed vs. stressed	Unstressed /ɪ/	42	63	20	-4.630	.000
	Stressed /ɪ/	42	94	42		
	Unstressed /ɪ/	42	63	20	-7.902	.000
	Stressed /i/	42	108	40		
Eng	Unstressed /ə/	42	58	19	-1.661	.104
	Unstressed /ɪ/	42	63	20		
Stressed	Stressed /ʌ/	42	87	32	-0.739	.464
	Stressed /ɪ/	42	94	42		
	Stressed /ʌ/	42	87	32	-2.574	.014
	Stressed /i/	42	108	40		
	Stressed /ɪ/	42	94	42		
Stressed /i/	42	108	40	-2.287	.027	

The effect of word stress on the vowel duration is seen in the duration difference between unstressed vowel and stressed vowel such as unstressed /ə/ vs. stressed /ʌ/ and unstressed /ɪ/ vs. stressed /ɪ/. The durations of unstressed vowels are significantly shorter than those of stressed vowels. There are also statistically significant durational differences between stressed vowels such as /ʌ/ vs. /i/ ( $t = -2.574, p = .014$ ) and /ɪ/ vs. /i/ ( $t = -2.287, p = .027$ ).

However, the duration difference between stressed /ʌ/ and stressed /ɪ/ is not statistically significant. In unstressed vowels /ə/ and /ɪ/, the durational difference is not statistically significant. Figure 2<sup>1</sup> shows the target vowel duration differences between unstressed and stressed vowel pairs for English speakers.

<sup>1</sup> In Figure 2, the duration bars in dark shade are statistically significant durational differences and duration bars in light shade show that the durational difference is not statistically significant, which is also the case for Figure 3, Figure 4, and Figure 5.

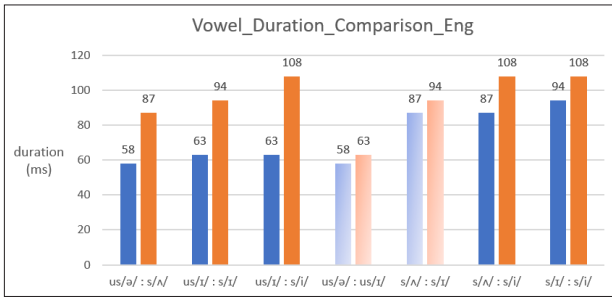


FIGURE 2 Vowel Duration in relation to Stress Placement in Native Speech

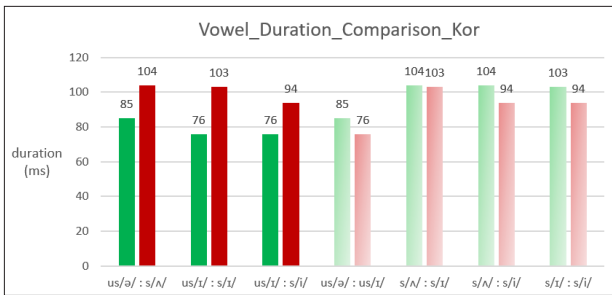


FIGURE 3 Vowel Duration in relation to Stress Placement in Nonnative Speech

2. Effect of Stress on Vowel Duration in the Speech of Korean Learners of English

Table 3 shows the duration of the unstressed and stressed vowels produced by Korean learners of English. The vowel durations are averaged across six participants for each target vowel.

As shown in the duration values, unstressed vowels are shorter than the counterpart stressed vowels in the speech produced by Korean Learners of English, which are the results similar to those of the native English speakers. The

TABLE 3

Vowel Durations and T-test Results in the Speech of Korean Learners of English

		<i>n</i>	<i>M</i>	<i>SD</i>	<i>t</i>	<i>p</i>	
Unstressed vs. stressed	Unstressed /ə/	42	85	31	-2.152	.037	
	Stressed /ʌ/	42	104	40			
	Unstressed /ɪ/	42	76	21	-5.312	.000	
	Stressed /ɪ/	42	103	34			
Kor Unstressed	Unstressed /ɪ/	42	76	21	-2.988	.005	
	Stressed /ɪ/	42	94	37			
	Unstressed	Unstressed /ə/	42	85	31	1.509	.139
		Unstressed /ɪ/	42	76	21		
Stressed	Stressed /ʌ/	42	104	40	0.114	.909	
	Stressed /ɪ/	42	103	34			
	Stressed	Stressed /ʌ/	42	104	40	1.025	.311
		Stressed /ɪ/	42	94	37		
		Stressed /ɪ/	42	103	34	1.674	.102
		Stressed /ɪ/	42	94	37		

duration of /ə/ in the unstressed first syllable is 85ms. And the duration of /ʌ/ in the stressed first syllable is 104ms. The duration difference is 19ms. The other two vowel pairs have about 20ms differences between unstressed and stressed vowels. The duration differences in the three unstressed and stressed vowel pairs (unstressed /ə/ vs. stressed /ʌ/, unstressed /ɪ/ vs. stressed /ɪ/, and unstressed /ɪ/ vs. stressed /i/) in Table 3 are statistically significant ( $t = -2.151, p = .037; t = -5.312, p = .000; t = 2.988, p = .005$  respectively). It should be also noted that the vowel durations in general in the speech of Korean learners of English are much longer than those of native English speakers, and the magnitude of durational difference due to stress is smaller in the speech of Korean learners of English compared with those of native English speakers even though there does exist statistically significant effect of stress on vowel duration for both of the two subject groups.

Even though there is statistically significant effect of stress on the vowel duration, there are not durational differences between stressed vowels, which is also the case between unstressed vowels. These durational characteristics suggest that the speech of Korean learners of English does not realize the inherent vowel durational difference of English, which is apparent in the speech of native English speakers.

3. Vowel Duration Comparison between the Two Subject Groups

Table 4 and Figure 4 show the target vowel duration differences between native English speakers and Korean learners of English. Overall, the vowel durations in the speech of Korean learners of English are longer than those of native English speakers, regardless of vowel type and stress placement. The durational differences between two subject groups are statistically significant. One exception is the vowel duration for stressed /ɪ/. The duration of this vowel is 94ms for native English speakers, and 103ms for Korean learners of English. Even though the duration difference is 9ms, the durational difference is not statistically

TABLE 4

Vowel Duration Comparison between the Two Subject Groups

		<i>n</i>	<i>M</i>	<i>SD</i>	<i>t</i>	<i>p</i>
Unstressed /ə/	Eng	42	58	19	-4.972	.000
	Kor	42	85	31		
Unstressed /ɪ/	Eng	42	63	20	-2.849	.007
	Kor	42	76	21		
Stressed /ʌ/	Eng	42	87	32	-3.397	.002
	Kor	42	104	40		
Stressed /ɪ/	Eng	42	94	42	-1.571	.124
	Kor	42	103	34		
Stressed /i/	Eng	42	108	40	2.430	.020
	Kor	42	94	37		

significant ( $t = -1.571, p = .124$ ). One thing to note is that for stressed /i/ the duration in the speech of native English speakers is longer than that in Korean learners of English. For Korean learners of English, the durations for stressed vowels (/ʌ/, /i/, and /i/) are around 100 ms and the durational differences are not statistically significant, while there are statistically significant durational differences between /ʌ/ vs. /i/ and /i/ vs. /i/ for native English speakers.

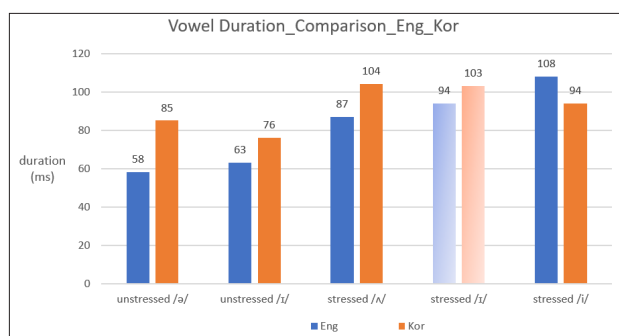


FIGURE 4 Vowel Duration Comparison in Native and Nonnative Speech

The nonnative vowel durations in percentage in comparison with the native vowel duration are shown in Figure 5. /ə/ in the unstressed first syllable has the greatest magnitude of durational difference between the two subject groups. For the unstressed /ə/, the vowel duration in the speech of Korean learners of English is 147% of the vowel duration in the speech of native English speakers, which is greater durational difference than that for the unstressed /i/. For other four vowels the magnitude of durational difference is smaller than that for the unstressed /ə/.

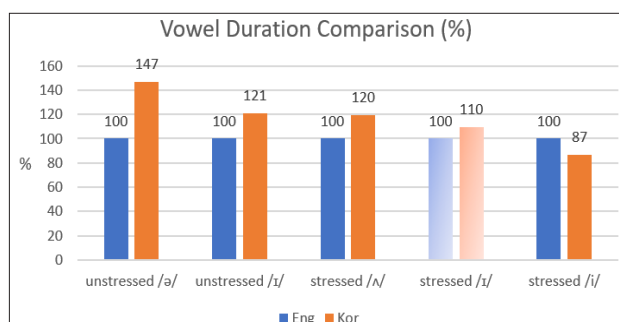


FIGURE 5 Comparison of Native and Nonnative Vowel Durations

Korean learners of English exhibit significantly longer averaged vowel durations than native English speakers. One exception is stressed /i/, which does not show statistically significant duration differences between the two subject groups.

#### 4. Stress and Vowel Quality in the Speech of Native English Speakers

Mean formant frequency values in Hz for the first formant(F1) and the second formant(F2) of target vowels are

shown in Table 5. The values are averaged across all the native English speakers.

As can be seen in Table 5, for native English speakers, the difference of the first and second formant frequency values between unstressed /ə/ and stressed /ʌ/ is statistically significant ( $t = -9.858, p = .000$  for F1;  $t = 6.705, p = .000$  for F2). The formant value difference for unstressed /i/ and stressed /i/ is statistically significant for F1 and not statistically significant for F2 ( $t = -2.901, p = .006$  for F1;  $t = -0.132, p = .896$  for F2). For unstressed vowels /ə/ and /i/, the first and second formant frequency values are significantly different from each other. For the three stressed vowels, the first and second formant value differences for /ʌ/ vs. /i/, /ʌ/ vs. /i/, and /i/ vs. /i/ are all statistically significant ( $p = .000$ ).

Figure 6 and Figure 7 depict the scatterplot of formant values for each speech token and they show the differentiated vowel space positions for each of the five target

TABLE 5

Mean and Standard Deviation of Formant Frequency Values for Native English Speakers

		n	M	SD	t	p		
Eng	Unstressed	Unstressed /ə/ F1	42	603	128	-9.858	.000	
		Stressed /ʌ/ F1	42	759	71			
	Unstressed vs. stressed	Unstressed /ə/ F2	42	1811	256	6.705	.000	
		Stressed /ʌ/ F2	42	1478	190			
	Unstressed	Unstressed /i/ F1	42	473	93	-2.901	.006	
		Stressed /i/ F1	42	521	72			
	Unstressed	Unstressed /i/ F2	42	2224	347	-0.132	.896	
		Stressed /i/ F2	42	2232	274			
	Eng	Unstressed	Unstressed /ə/ F1	42	603	128	6.601	.000
			Unstressed /i/ F1	42	473	93		
Unstressed		Unstressed /ə/ F2	42	1811	256	-7.428	.000	
		Unstressed /i/ F2	42	2224	347			
Stressed		Stressed /ʌ/ F1	42	759	71	19.234	.000	
		Stressed /i/ F1	42	521	72			
Stressed		Stressed /ʌ/ F2	42	1478	190	-18.690	.000	
		Stressed /i/ F2	42	2232	274			
Stressed		Stressed /ʌ/ F1	42	759	71	39.498	.000	
		Stressed /i/ F1	42	366	54			
Stressed	Stressed /ʌ/ F2	42	1478	190	-37.921	.000		
	Stressed /i/ F2	42	2754	247				
Stressed	Stressed /i/ F1	42	521	72	14.295	.000		
	Stressed /i/ F1	42	366	54				
Stressed	Stressed /i/ F2	42	2232	274	-12.776	.000		
	Stressed /i/ F2	42	2754	247				

vowels in the speech of native English speakers. The vowel space comparison between unstressed /ə/ and /ɪ/ is illustrated on the left of the Figure 6, and the vowel space comparison between the three stressed vowels /ʌ/, /ɪ/, and /i/ is illustrated on the right of Figure 6. The vowel space of each vowel is seen distinctive from each other. Figure 7 depicts the vowel spaces of all the five target vowels. As is seen in Figure 7, all the five target vowels are distributed distinctive from one another in the vowel space.

With the one exception of F2 value difference for un-

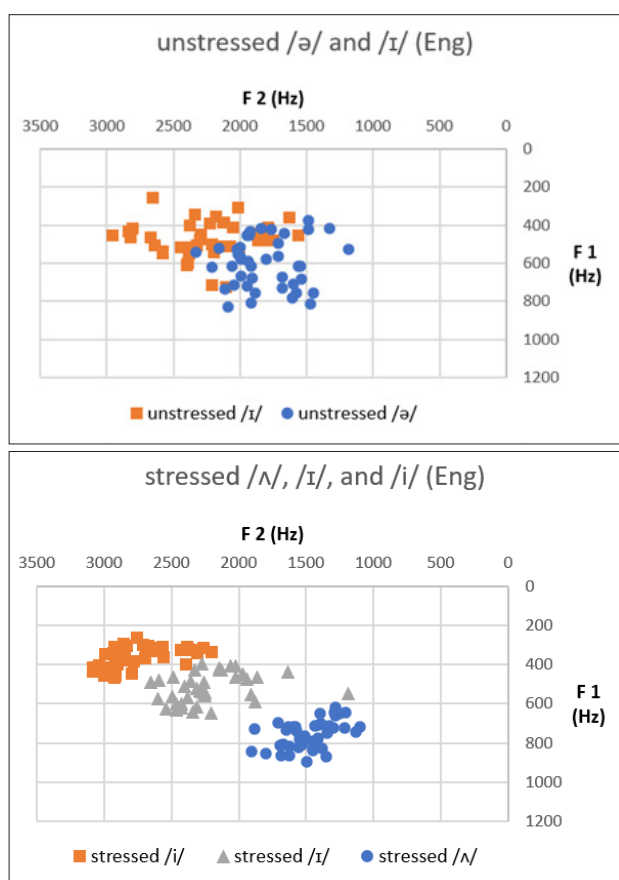


FIGURE 6 Vowel Space of Unstressed and Stressed Vowels in Native English Speech

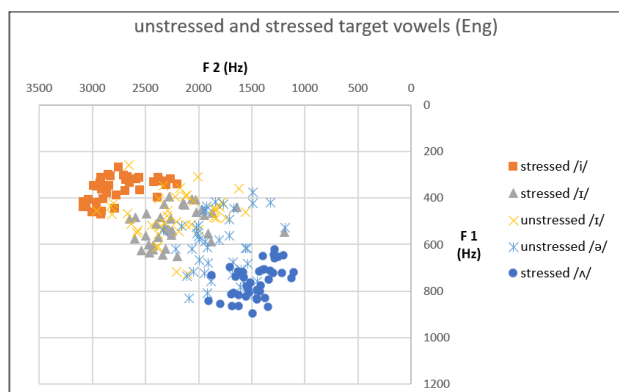


FIGURE 7 Vowel Space of the Five Vowels in Native English Speech

stressed and stressed /ɪ/, all the formant values are significantly different, which means all the five vowels have their own position distinctive from one another in the vowel space.

### 5. Stress and Vowel Quality in the Speech of Korean Learners of English

Mean formant frequency values for the first formant and the second formant of target vowels are shown in Table 6. The values are averaged across all the Korean learners of English.

As can be seen in Table 6, the differences of the first and second formant frequency values between unstressed /ə/ and stressed /ʌ/ are not statistically significant for Korean learners of English ( $t = -2.189, p = .034$  for F1;  $t = 1.214, p = .232$  for F2). The formant value difference for unstressed /ɪ/ and stressed /ɪ/ is not statistically significant for F1 and F2

TABLE 6

Mean and Standard Deviation of Formant Frequency Values for Korean Learners of English

		<i>n</i>	<i>M</i>	<i>SD</i>	<i>t</i>	<i>p</i>		
Unstressed vs. stressed	Unstressed /ə/ F1	42	658	83	-2.189	.034		
	Stressed /ʌ/ F1	42	696	117				
	Unstressed /ə/ F2	42	1264	161	1.214	.232		
	Stressed /ʌ/ F2	42	1226	178				
	Unstressed /ɪ/ F1	42	386	61	-1.620	.113		
	Stressed /ɪ/ F1	42	404	72				
Unstressed	Unstressed /ɪ/ F2	42	2389	259	0.836	.408		
	Stressed /ɪ/ F2	42	2355	328				
	Kor	Unstressed /ə/ F1	42	658	83	19.565	.000	
		Unstressed /ɪ/ F1	42	386	61			
		Unstressed	Unstressed /ə/ F2	42	1264	161	-25.712	.000
			Unstressed /ɪ/ F2	42	2389	259		
Stressed		Stressed /ʌ/ F1	42	696	117	14.808	.000	
		Stressed /ɪ/ F1	42	404	72			
	Stressed /ʌ/ F2	42	1226	178	-21.351	.000		
	Stressed /ɪ/ F2	42	2355	328				
	Stressed	Stressed /ʌ/ F1	42	696	117	16.976	.000	
		Stressed /ɪ/ F1	42	383	72			
	Stressed	Stressed /ʌ/ F2	42	1226	178	-35.091	.000	
		Stressed /ɪ/ F2	42	2428	239			
	Stressed	Stressed /ɪ/ F1	42	404	72	1.852	.071	
		Stressed /ɪ/ F1	42	383	72			
Stressed /ɪ/ F2		42	2355	328	-1.799	.079		
Stressed /ɪ/ F2		42	2428	239				

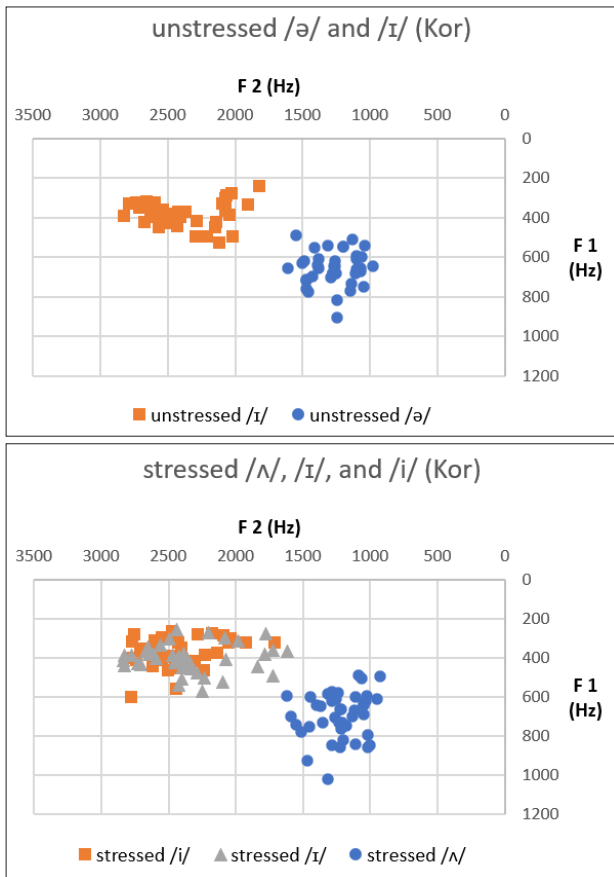


FIGURE 8 Vowel Space of Unstressed and Stressed Vowels in Nonnative English

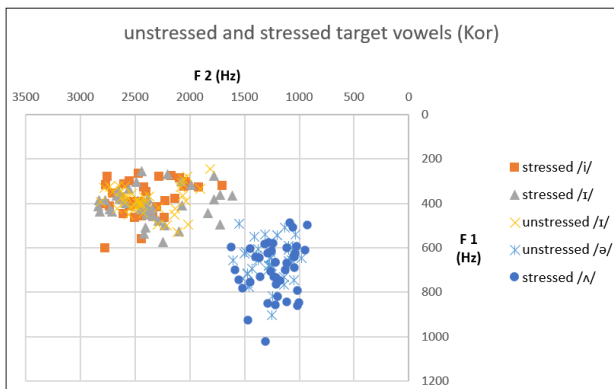


FIGURE 9 Vowel Space of the Five Vowels in Nonnative English Speech

( $t = -1.620, p = .113$  for F1;  $t = 0.836, p = .408$  for F2). For unstressed vowels, /ə/ and /ɪ/ the formant frequency values are all significantly different ( $p = .000$ ), and for the three stressed vowels, the first and second formant value differences for /ʌ/ vs. /ɪ/ and /ʌ/ vs. /i/ are all statistically significant ( $p = .000$ ), and the first and second formant value differences for /ɪ/ vs. /i/ are not statistically significant ( $t = 1.852, p = .071$  for F1;  $t = -1.799, p = .079$  for F2). Scatter plots of F1 and F2 values of target vowels are shown in Figure 8 and Figure 9 for Korean learners of English.

As can be seen in Figure 8 and 9, the distributions for stressed /i/, stressed /ɪ/, and unstressed /ɪ/ are overlapped and the distributions for stressed /ʌ/ and unstressed /ə/ are overlapped, which shows that the vowels, stressed /i/, stressed /ɪ/, and unstressed /ɪ/ have almost the same vowel quality, and it is the case for stressed /ʌ/ and unstressed /ə/. Korean learners of English seem to categorize the five vowels in two regardless of stress placement, which implicates that their nonnative English vowels were influenced by the phonological characteristics of their native Korean language. The Korean language does not have lexical stress and has only one vowel corresponding to the different two English vowels /ɪ/ and /i/.

### 6. Vowel Quality Comparison between the Two Subject Groups

Table 7 shows the mean first formant(F1) and second formant(F2) frequency values in Hz for native English speakers and Korean learners of English. The formant values for all the target vowels except the first formant of stressed /i/ have statistically significant differences between two speaker groups.

The vowel space for the two speaker groups is visualized in Figure 10. As can be seen in the vowel distribution in Figure 10, the target vowels for native English speakers have some distance from each other, except that unstressed

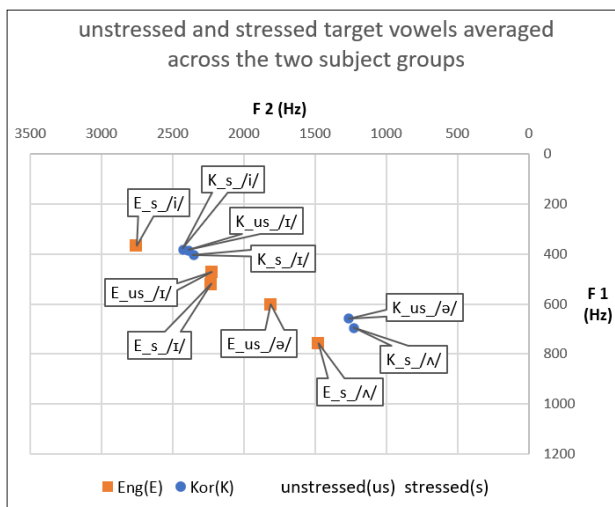
TABLE 7

Mean and Standard Deviation of Formant Frequency Values for the Two Speaker Groups

		<i>n</i>	<i>M</i>	<i>SD</i>	<i>t</i>	<i>p</i>
Unstressed /ə/	Eng F1	42	603	128	-2.520	.016
	Kor F1	42	658	83		
	Eng F2	42	1811	256	12.334	.000
	Kor F2	42	1264	161		
Unstressed /ɪ/	Eng F1	42	473	93	5.249	.000
	Kor F1	42	386	61		
	Eng F2	42	2224	347	-2.627	.012
	Kor F2	42	2389	259		
Stressed /ʌ/	Eng F1	42	759	71	2.851	.007
	Kor F1	42	696	117		
	Eng F2	42	1478	190	9.199	.000
	Kor F2	42	1226	178		
Stressed /i/	Eng F1	42	521	72	10.332	.000
	Kor F1	42	404	72		
	Eng F2	42	2232	274	-2.423	.020
	Kor F2	42	2355	328		
Stressed /i/	Eng F1	42	366	54	-1.545	.130
	Kor F1	42	383	72		
	Eng F2	42	2754	247	9.558	.000
	Kor F2	42	2428	239		

/ɪ/ is close to stressed /i/. The effect of lack of stress on the vowel reduction is shown in the speech of native English speakers. Compared with the stressed /ʌ/, the unstressed /ə/ is higher and fronter and more centralized. Unstressed /ɪ/ is slightly higher than the stressed /i/ in the vowel space.

In contrast, the speech of Korean learners of English shows that unstressed /ɪ/, stressed /i/, and stressed /i/ are very close to each other in their position in the vowel space. Korean learners of English have unstressed /ə/ and stressed /ʌ/ that are close to each other. Overall, Korean learners of English do not show the effect of stress on the vowel formant structure and they do not differentiate /ɪ/ from /i/ regardless of stress. They also do not differentiate unstressed /ə/ from stressed /ʌ/ in the vowel formant structure.



**FIGURE 10** Vowel Space of Target Vowels in Native and Nonnative English Speech

In regard to the vowel space differences between two subject groups, stressed /i/ and /ɪ/, and unstressed /ɪ/ in the speech of Korean learners of English are in between stressed /i/ and stressed /ɪ/ in the speech of native English speakers. And unstressed /ə/ and stressed /ʌ/ for Korean learners of English are at the retracted positions from those of native English speakers. The vowel space of Korean learners of English might lead to intelligibility problem as it is the vowel quality correlate of English lexical stress that is consistently processed categorically (Ghosh & Levis, 2021).

## V. CONCLUSION

In this study, we focused on the comparison between native and nonnative speakers' control of the duration and the vowel space in relation to stress placement in English content words. The results of the study show that Korean learners of English have their own durational patterns and formant structures distinctive from those of native English speakers.

For the lengthening effect of word stress on the vowel duration, the durational differences between the unstressed

and stressed vowel pairs are all statistically significant for both of the subject groups. However, the duration ratios between the vowel pairs for Korean learners of English are much smaller than those for native English speakers.

It is notable that Korean learners of English show some difficulty in realizing the duration of the stressed vowel /i/. Their /i/ is much shorter than native English speakers' /i/. This might lead to intelligibility problem in the part of native English speakers and hinder effective communication. For example, the word 'teen' produced by Korean learners of English might be perceived as 'tin', and the word 'sheep' produced by Korean learners of English might be perceived as 'ship'. Korean learners of English should practice lengthening the duration of /i/ so that the vowel can have enhanced duration that is in contrast to the duration of the vowel /ɪ/.

In regard to the effect of stress on the vowel quality, the results of the study show that unstressed vowels /ə/ and /ɪ/ in the speech of Korean learners of English have significantly different first and second formant frequency values and distinctive positions in the vowel space from those of native English speakers. Language-specific vowel inventory as well as absence of lexical stress in the Korean language seems to make Korean learners of English experience difficulties in overcoming the first language transfer in the production of unstressed and reduced vowels /ə/ and /ɪ/.

For the unstressed vowel /ə/, Korean learners of English need to train themselves to shorten the duration of the vowel and realize the centralized position of the vowel in the vowel space. Moreover, based on the theory of production and perception relatedness, Korean learners of English might not be able to perceive the reduced quality of the unstressed vowel /ə/ in the word 'attention' and they might mistakenly perceive the word as 'tension'.

Overall, Korean learners of English should pay attention to the duration and the vowel quality of English stressed and unstressed vowels. With repeated production and perception practices, they should be familiarized with the intrinsic vowel duration and formant structure and the changes of those phonetic characteristics caused by stress placement, especially shortening and centralization in the vowel space of the unstressed vowels.

In sum, durational enhancement and reduction due to stress placement exist for both of the native and nonnative speaker groups. However, Korean learners of English show their own acoustic phonetic characteristics in duration, which show the native Korean language transfer to their nonnative English vowels. Vowel intrinsic duration, vowel inventory, and the absence of word stress of the Korean language make Korean learners of English have difficulties in producing phonetic contrasts of English vowels.

As unstressed vowel reduction in terms of duration and vowel quality is one of the important factors determining the intelligibility of the nonnative speech of Korean learners of English, the phonetic characteristics of reduced English vowels in relation to stress placement should be emphasized in teaching English pronunciation. In developing a pronunciation training program for English vowels,

the speech examples and the visual data of the phonetic characteristics for each vowel should be included so that they can help Korean learners of English differentiate the target vowels from one another and produce them distinctively. Future studies that investigate the effect of explicit teaching methods utilizing the data of vowel duration and vowel quality will help the L2 English teachers to elicit an effective approach to the teaching of English vowel pronunciation.

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