

An Acoustic Study of English Sentence Stress and Rhythm Produced by Korean Speakers

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ABSTRACT

The purpose of this paper is to examine how Korean speakers realize English stress and rhythm at the sentence level, and investigate what different acoustic characteristics of English sentence stress and rhythm Korean speakers have, compared with those of American English speakers. Stressed words in the sentence were analyzed in terms of duration, fundamental frequency, and intensity of the stressed vowel in the word with neutral stress and with emphatic stress, respectively. According to the results, when the words had emphatic stress, both Koreans' and Americans' F0 and intensity of the stressed vowel were higher than those with neutral stress. Korean speakers of English realized the sentence stress with shorter vowel duration and higher F0 than American English speakers when the words had emphatic stress. The analysis of the timing of the sentence with increased unstressed syllables showed that both Americans and Koreans produced the sentence with longer duration as the number of unstressed syllables increased. However, the duration of unstressed syllables between stressed syllables by Koreans was longer than that by Americans. Americans seemed to produce unstressed syllables between stressed syllables faster than Koreans for regular intervals of stressed syllables. This analysis implies that if there are more unstressed syllables between stressed syllables, Koreans might produce unstressed syllables and the whole sentence with longer duration.

Keywords: sentence stress, rhythm, duration, fundamental frequency, intensity

1. Introduction

Stress and rhythm are suprasegmental features along with intonation existing above individual consonants and vowels and play an important role in communication. Stress and rhythm are closely interrelated in the language and have two functions that help speakers indicate word stress and sentence stress and that help listeners differentiate the most prominent information from the other parts in an utterance (Chun, 2002).

Stress is defined as a feature which makes a syllable prominent and marked by three features such as fundamental frequency, duration, and intensity (Bolinger, 1958; Fry, 1958).

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Chun (2002:7) asserts that stress patterns are important in English “because they distinguish one word from another, and because rhythm of the language is determined largely by strong ‘beats’ falling on the stressed syllables of phrases and sentences.” Crystal (1985:266) defines rhythm as “the perceived regularity of prominent units in speech,” and regularities are discussed with respect to patterns of stressed versus unstressed syllables, syllable length, and pitch.

English is known as a stress-timed language because the syllable lengths are irregular and the rhythm is determined by the place that the stresses come in a word and in a sentence (Chun, 2002). According to the *Concise Oxford Dictionary of Linguistics* (Matthews, 1997), in a stress-timed language, “the intervals between stressed syllables in speech are either equal or at least more nearly equal than the intervals between the nucleus of each successive syllable and the next.” Stress-timed languages are also called “irregular-syllable” languages, and English is isochronous because the stressed syllables tend to occur at regular intervals (Chun, 2002). No matter how many unstressed syllables there are between stressed syllables, the length of the interval between stressed syllables tend to be the same. So the more unstressed syllables there are between two stressed syllables, the shorter each syllable will be. Meanwhile, Korean is known as a syllable-timed language or a regular-syllable language (Martin, 1951). In syllable-timed languages, the length of syllables is almost equal, so if a sentence has more syllables, the duration will be longer.

There are studies about English stress and rhythm. Related to word stress, Yang (2002) examined that acoustical difference in the first two syllables of a stressed word produced by Americans and Koreans, and found out that Korean speakers of English whose TOEFL scores were very high had little difference in producing words from Americans. However, they showed the difference in producing the diphthong such as *making* and the second syllable stressed words such as *consider* and *dispute* in terms of fundamental frequency, duration, and intensity. This experiment shows that the three parameters mark the syllable prominence well, and suggests that if Koreans speakers have lower fluency in English, they may have more difference in producing the English words from native speakers of English.

A study on sentence stress of Mandarin speakers of English by Chen et al. (2001) found that Mandarin speakers could tell the difference between stressed words and unstressed words in terms of F0, duration, and intensity. They also marked stress in their sentence production, but their acoustic characteristics of stress were not the same as American English speakers. Mandarin speakers produced stressed words with a higher F0 and shorter duration, and produced unstressed words with a higher F0 and greater intensity than American speakers. However, this study implies that there is no critical divergence in American English sentence stress between these speakers.

Lee and Kim (2005) examined Korean learners’ speech-timing of English before and after instruction and compared it to native speech. They also tried to investigate if speech-timing is

measurable. They measured the duration difference between the adjacent stressed and unstressed syllables within a foot with the pair-wise variability method, which was used by Low et al. (2000) and Jian (2004). This study found that before instruction Korean learners' speech was small for the pair-wise variability between the adjacent stressed and unstressed syllables within a foot and very big for the variability among adjacent feet within the utterance. But after instruction the learners' speech greatly improved in their pair-wise variability of syllable sequence toward native speech. This study implies that Korean English is interfered by syllable-timing and that the speech timing difference between Korean English and American English is measurable in terms of duration of the stressed and unstressed syllables.

Usually sentence stress falls on the content words such as nouns, verbs, adjectives, adverbs, demonstratives, and interrogatives in the sentence, but function words such as articles, prepositions, personal pronouns, possessive adjectives, relative pronouns, and common conjunctions do not have sentence stress except when they have special focus or emphasis in the discourse (Prator & Robinett, 1985). On the whole, in English major sentence stress comes on the stressed syllable of the last content word in the sentence, which is called unmarked neutral stress. However, sentence stress can have different functions and realize differently from the neutral sentence stress when it is related to information focus, emphasis, or contrast. Sentence stress is marked by fundamental frequency, duration, and intensity (Chun, 2002).

This paper examines how Korean speakers realize English stress and rhythm at the sentence level, and investigates what different acoustic characteristics of English sentence stress and rhythm Korean speakers have, comparing their sentence stress and rhythm to those of native speakers of English. Because English and Korean are different from each other in terms of stress and rhythm, it is supposed that Koreans realize English stress and rhythm differently from those of native speakers of English.

2. Method

For this study, ten subjects (four Americans and six Koreans) participated in this experiment. All the subjects are male to reduce the difference between genders. Americans are from Nebraska, North Carolina, Ohio, and Pennsylvania, and teach English at public middle schools and elementary schools in Suwon and Hwasung. Koreans are from Seoul and Kyeonggi-do, and graduate students in MBA program at Ajou University in Suwon. Their English proficiency level is advanced and their TOEIC scores are between 730 and 850 out of 990. Largely, they use English for business. The average height of Americans is 178 cm, and the average height of Koreans is 172 cm.

They read the following sentences three times and among them the best sentence was

selected for each sentence. The sentences (1a) and (1b) were read with a neutral stress first and then (1a1, 2, 3) and (1b1, 2, 3) with an emphasis on capitalized word. When the sentence receives neutral stress, the stressed syllable of the last content word receives the stress. Therefore, in the sentences (1a) and (1b), the vowel [ʌ] and the diphthong [eɪ] in the words *lunch* and *conversation* are stressed like the same vowels in the sentences (1a3) and (1b3). To differentiate neutral stress from emphatic stress, the subjects were asked to read the sentences (1a3) and (1b3) with more emphasis on the last words unlike the sentences (1a) and (1b). Sentences were extracted from Prator and Robinett (1985:40).

(1)

- a. A drugstore is the place to have lunch.
 - a1. A DRUGSTORE is the place to have lunch.
 - a2. A drugstore is the PLACE to have lunch.
 - a3. A drugstore is the place to have LUNCH.

- b. We were enchanted by her intelligent conversation.
 - b1. We were ENCHANTED by her intelligent conversation.
 - b2. We were enchanted by her INTELLIGENT conversation.
 - b3. We were enchanted by her intelligent CONVERSATION.

(2) a. BOYS NEED MONEY.

- b. The BOYS will NEED MONEY.
- c. The BOYS will NEED some MONEY.
- d. The BOYS will be NEEDING some MONEY.
- e. The BOYS will be NEEDING some of their MONEY.

In the above (2a)-(2e) sentences I explained to the subjects before recording that three capitalized content words are stressed in the sentence, and the other uncapitalized function words are not stressed. They read the sentences (2a)-(2e) with neutral stress. The recording and acoustical analysis were done with Pitch Works (Version 6.4 by Scicon R&D).

From the sentences (1a), (1a1-3), (1b), and (1b1-3), only the content words *drugstore*, *place*, *lunch*, *enchanted*, *intelligent*, and *conversation* were selected and analyzed in terms of fundamental frequency, duration, and intensity. First, I measured the duration of each sentence and the stressed word, and the stressed syllable and the vowel in the word with neutral stress and emphatic stress. Because the sentences from (2a) to (2e) finished with a vowel, I measured the duration of the sentence until the point that intensity level of the waveform minimized even though nothing was shown on the spectrogram. In the case of the word *intelligent*, the stressed

syllable -tel- is connected with the same consonant [l] in the next syllable -li-. So I measured the duration of the syllable -tel- with a half of the whole duration of the consonant [l]. F0 and intensity of the stressed vowel were measured at the highest point of the part. I measured each parameter standing for stress by watching waveform, F0 traces, and spectrogram, and by listening to the sound of that part. The wave form was zoomed in on to find the end of the first syllable and the onset of the next syllable. <Figure 1> shows the waveform and spectrogram of the word *drugstore*. The arrows under the figure indicate the beginning and the ending of the syllables and vowels in the word.

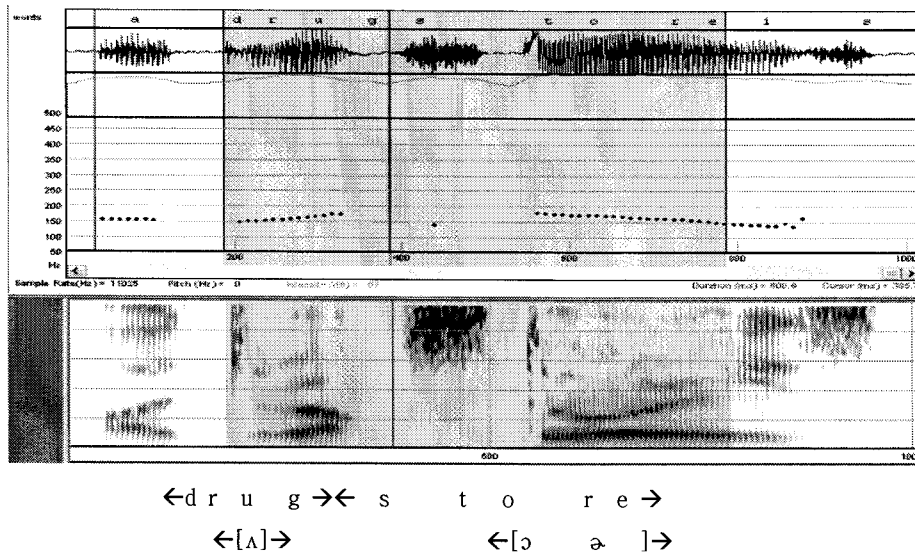


Figure 1. Division of the syllables of the word 'drugstore'

Sentences (2a) - (2e) are for analyzing timing of the sentence. I measured the duration of each sentence, the duration of three stressed syllables, and the duration of unstressed syllables. As the number of unstressed syllables (function words) increases, the change of timing was analyzed. The duration between stressed syllables in the sentences (2a), (2c), and (2e) was measured in order to examine how Korean speakers realize English rhythm as a stress-timed language. The reason that I chose three of five sentences is that they change the number of unstressed syllables between the stressed syllables of the subject and the main verb, and between the verb and the object. The data for the duration, F0 and intensity of the stress vowel, and the duration of the syllables in the sentences from (2a) to (2e) were statistically analyzed from paired t-tests with SPSS (Version 12.0).

3. Results and discussion

3.1 Analysis of sentence stress

From the sentences (1a), (1a1-3), (1b), and (1b1-3), the following results were obtained. <Table 1> shows the average duration of six content words and the stressed syllable in the words when they have neutral stress. Because the words *place* and *lunch* among six words are monosyllabic words, the duration of the word and the syllable of those words are equal. The ratio means the proportion of each content word out of the whole sentence in terms of the duration. According to <Table 1>, the duration differences of the stressed words are not very big between Koreans and Americans when the sentence has neutral stress except the words *intelligent* and *conversation*. The duration of the whole sentence of Korean speakers is a little longer than Americans. But the duration of the words *drugstore*, *intelligent*, and *conversation* of Korean subjects is shorter than that of American subjects; especially, the duration differences of *intelligent* and *conversation* are 127 ms, and 104 ms. The ratio of these words to the sentence of Koreans is smaller than that of Americans. The difference of the duration of the stressed syllable with neutral stress between Koreans and Americans is also not very big. The difference is less than 30 ms.

Table 1. Comparison of the average duration of the stressed word and the stressed syllable with neutral stress

unit (ms)	word	stressed syllable	sentence	ratio	unit (ms)	word	stressed syllable	sentence	ratio
	drugstore	drug-				enchanted	-chan-		
Ame	576	239	2191	0.26	Ame	599	274	2972	0.2
Kor	560	226	2334	0.24	Kor	620	275	3079	0.2
Diff	-16	-13	143	0.02	Diff	21	1	107	0
	place	place				intelligent	-tel-		
Ame	313	313	2191	0.14	Ame	671	179	2972	0.23
Kor	336	336	2334	0.14	Kor	544	178	3079	0.18
Diff	23	23	143	0	Diff	-127	-1	107	-0.05
	lunch	lunch				conversation	-sa-		
Ame	440	440	2191	0.2	Ame	843	267	2972	0.28
Kor	465	465	2334	0.2	Kor	739	276	3079	0.24
Diff	25	25	143	0	Diff	-104	9	107	-0.04

<Table 2> summarizes the average duration of the stressed words and the stressed syllables when they are emphasized. The ratio of the duration of the stressed word to the whole sentence of Korean speakers is smaller than that of American speakers except the word *intelligent*.

It means that the duration of the stressed word of Korean speakers is shorter than that of American speakers. In fact, when the words were emphasized, Korean speakers produced the words much more shortly than American speakers except the word *lunch*. The duration of the stressed syllable in the words with emphatic stress produced by Koreans is also shorter than that produced by Americans except *lunch*. There were no specific evidences such as inserting a vowel after the consonant [ʃ] that Korean speakers produced the word *lunch* longer than American speakers.

Table 2. Comparison of the average duration of the stressed word and the stressed syllable with emphatic stress

unit (ms)	word	stressed syllable	sentence	ratio	unit (ms)	word	stressed syllable	sentence	ratio
	drugstore	drug-				enchanted	-chan-		
Ame	678	271	2422	0.28	Ame	788	343	3142	0.25
Kor	602	238	2353	0.26	Kor	706	287	3178	0.22
Diff	-76	-33	-69	-0.02	Diff	-82	-56	36	-0.03
	place	place				intelligent	-tel-		
Ame	484	484	2534	0.18	Ame	838	243	3180	0.26
Kor	371	371	2387	0.16	Kor	820	197	3071	0.27
Diff	-113	-113	-147	-0.02	Diff	-18	-46	-109	0.01
	lunch	lunch				conversation	-sa-		
Ame	498	498	2188	0.23	Ame	940	304	3066	0.3
Kor	520	520	2320	0.22	Kor	828	290	3066	0.27
Diff	22	22	132	-0.01	Diff	-12	-14	0	-0.03

On the basis of <Table 1> and <Table 2>, we can compare the average duration of the stressed word and the stressed syllable with neutral stress to that with emphatic stress. Both Koreans and Americans produced the stressed word and the stressed syllable with longer duration when the word was emphasized than when it had neutral stress. When the sentence had neutral stress, Korean speakers had longer syllable duration in the words *place*, *lunch*, *enchanted* and *conversation*. However, when the word had emphatic stress, Americans had longer syllable duration in the words *drugstore*, *place*, *enchanted*, *intelligent* and *conversation* than Koreans. Only the duration of *lunch* produced by Koreans was longer than that of Americans.

Table 3. Comparison of the average duration of the stressed vowel

Duration (ms) of the stressed vowel with neutral stress					Duration (ms) of the stressed vowel with emphatic stress				
	American	Korean				American	Korean		
word	Ave./s.d.	Ave./s.d.	t	p	word	Ave./s.d.	Ave./s.d.	t	p
drugstore	87/10.1	76/17.4	-1.17	0.285	drugstore	95/15.5	88/2.8	-0.82	0.444
place	107/24.8	106/28.8	-0.03	0.978	place	161/37.8	133/41	-1	0.356
lunch	124/22.9	97/13.9	-1.96	0.098	lunch	121/38.9	115/17.2	-0.27	0.799
enchanted	121/22.3	114/30.3	-0.38	0.72	enchanted	146/13.2	108/34.8	-2.02	0.089
intelligent	71/9.2	67/16.6	-0.47	0.654	intelligent	84/16.7	76/12.2	-0.79	0.455
conversation	133/42.9	148/12	0.69	0.516	conversation	155/27.3	146/22.8	-0.49	0.636

*p<0.05

<Table 3> compares the duration of the stressed vowel with neutral stress and with emphatic stress between Korean speakers and American English speakers. Even though the significant difference is not found in the duration of the stressed vowel between Koreans and Americans, the duration of the stressed vowel of Koreans is shorter than that of Americans except the duration of the diphthong [eɪ] in the word *conversation* when the sentence has neutral stress. Americans have 27 ms longer average duration in the vowel [ʌ] of the word *lunch*, while Koreans have 15 ms longer average duration in the diphthong [eɪ] of the word *conversation*. When the words have emphatic stress, the duration of the stressed vowel in each word produced by Korean speakers is shorter than that by Americans. The duration difference between Koreans and Americans is big in the diphthong [eɪ] of the word *place* (28 ms) and in the vowel [æ] of the word *enchanted* (38 ms).

Table 4. Comparison of the F0 of the stressed vowel

F0 (Hz) of the stressed vowel with neutral stress					F0 (Hz) of the stressed vowel with emphatic stress				
	American	Korean				American	Korean		
word	Ave./s.d.	Ave./s.d.	t	p	word	Ave./s.d.	Ave./s.d.	t	p
drugstore	141/20.1	168/28.7	1.56	0.171	drugstore	158/47	188/41.3	0.98	0.363
place	108/19.3	167/19.7	4.26	0.005*	place	156/35.3	183/34.3	1.12	0.306
lunch	110/25.3	142/26.2	1.78	0.125	lunch	130/34.5	176/35.8	1.85	0.114
enchanted	137/19.1	178/23.2	2.68	0.037*	enchanted	168/34.1	184/15	0.86	0.424
intelligent	126/12.2	158/4.9	4.93	0.003*	intelligent	150/31.7	175/18	1.37	0.219
conversation	110/27.9	147/8.9	2.54	0.044	conversation	122/23.7	161/19.9	2.49	0.047*

*p<0.05

<Table 4> shows the F0 difference of the stressed vowel between Korean speakers of English and American English speakers. When the words have neutral stress, for Koreans, F0 ranges from 142 Hz to 178 Hz, and the highest F0 in the stressed vowel is 178 Hz in the word *enchanted*. The F0 of the stressed vowel of Americans ranges from 110 Hz to 141 Hz, and the highest F0 is 141 Hz in the stressed vowel of the word *drugstore*. With neutral stress, the F0 differences of the words *place*, *enchanted* and *intelligent* between Koreans and Americans are significant ($p=0.005$, $p=0.037$, $p=0.003$). When the words have emphatic stress, F0 of the stressed vowel of Koreans ranges from 161 Hz to 188 Hz, and the highest F0 is 188 Hz in the stressed vowel of the word *drugstore*. For Americans, F0 ranges from 122 Hz to 168 Hz, and the highest F0 is 168 Hz in the stressed vowel of the word *enchanted*. With emphatic stress, the F0 difference in the stressed vowel of the word *conversation* between Koreans and Americans is significant ($p=0.047$). Both Koreans and Americans produced the stressed vowel with higher F0 when the word was emphasized than when the word had neutral stress. However, in both cases, Korean speakers had higher F0 than Americans.

Table 5. Comparison of the intensity of the stressed vowel

Intensity (dB) of the stressed vowel with neutral stress					Intensity (dB) of the stressed vowel with emphatic stress				
word	American Ave./s.d.	Korean Ave./s.d.	t	p	word	American Ave./s.d.	Korean Ave./s.d.	t	p
drugstore	81/5.6	84/5.3	0.59	0.578	drugstore	83/7.5	85/4.9	0.29	0.784
place	77/4.6	79/5	0.59	0.576	place	84/4.7	80/6.9	-0.90	0.403
lunch	78/4.5	80/5.8	0.54	0.606	lunch	81/4.8	85/4	1.19	0.276
enchanted	82/2.4	78/3.6	-1.86	0.112	enchanted	83/1.5	80/2.5	-2.56	0.043*
intelligent	82/2.5	79/3.6	-1.52	0.179	intelligent	86/2.2	81/3.7	-2.44	0.051
conversation	80/4.2	77/4.3	-0.99	0.36	conversation	83/1.5	81/5.4	-0.89	0.410

* $p<0.05$

<Table 5> compares the intensity difference between Koreans and Americans when the words have neutral stress and emphatic stress. When the word has neutral stress, Americans have higher intensity of the stressed vowels in the words *drugstore*, *place*, and *lunch* than Koreans, but Koreans have higher intensity in the other three words *enchanted*, *intelligent*, and *conversation* than Americans. When the word receives an emphasis, Americans have higher intensity of the stressed vowel in the words *place*, *enchanted*, *intelligent*, and *conversation*, and Koreans have higher intensity of the stressed vowel in the words *drugstore* and *lunch*. With neutral stress, the stressed vowel intensity of Americans ranges from 77 dB to 82 dB, and the stressed vowel intensity of Koreans ranges from 77 dB to 84 dB. With emphatic stress, the stressed vowel intensity of Americans ranges from 81 dB to 86 dB, and the stressed vowel

intensity of Koreans ranges from 80 dB to 85 dB. Both Americans and Koreans have higher vowel intensity in the words with emphatic stress than with neutral stress.

The results of duration, F0, and intensity of the stressed vowel indicate that Korean speakers use F0 most in three factors for sentence stress, compared to Americans. The result that the duration of the vowel produced by Koreans is shorter than that of Americans reflects that Koreans produce English stressed vowels with similar duration of unstressed vowels like a syllable-timed language.

3.2 Analysis of sentence timing

In order to analyze the sentence timing, I measured the duration of each sentence, and the duration of three stressed syllables and the other unstressed syllables in the sentence. Then, the duration per unstressed syllable derived from the result that the duration of the unstressed syllables was divided by the number of the unstressed syllables. The ratio is the duration of three stressed syllables and the other unstressed syllables to the sentence.

Table 6. American speakers' average sentence duration with increased syllables (ms)

(ms)		sentence	3 stressed syllables (ratio)	unstressed syllables (ratio)	number of unstressed syllables	duration per unstressed syllable	increased sentence duration
(2)a	ave.	1094	923 (0.84)	171 (0.16)	1	171	
	s.d.	172.9	150.6				
(2)b	ave.	1505	971 (0.65)	534 (0.35)	3	178	411 (37%)
	s.d.	131.9	138.3				
(2)c	ave.	1677	891 (0.53)	786 (0.47)	4	197	172 (11%)
	s.d.	202.7	125.3				
(2)d	ave.	1975	862 (0.44)	1113 (0.56)	6	186	298 (17%)
	s.d.	254.9	96.3				
(2)e	ave.	2106	846 (0.4)	1260 (0.6)	8	158	131 (6%)
	s.d.	234.3	65.4				

<Table 6> summarizes the duration of the sentences from (2a) to (2e) produced by American English speakers. The sentence (2a) has three stressed syllables and one unstressed syllable. The average duration of the sentence (2a) is 1094 ms, and the duration of one unstressed syllable is 171 ms. The sentence (2b) lasts 1505 ms long, and it has two more unstressed syllables than the sentence (2a). The duration difference between (2a) and (2b) is 411 ms (37% increased), and the average duration of each unstressed syllable is 178 ms. There is one more unstressed syllable increased in the sentence (2c). The duration difference between (2b) and (2c) is 172 ms (11% increased), and the average duration of the unstressed syllable is

197 ms. The sentence (2d) has two more unstressed syllables than (2c) and has 298 ms longer duration (17% increased). The average duration per unstressed syllable is 186 ms. The sentence (2e) is 131 ms longer than the sentence (2d) (6% increased), and the average duration per unstressed syllable is 158 ms. The duration of three stressed syllables increases in the sentence (2b), but gradually decreases from the sentence (2c). The duration of the unstressed syllables increases as the number of the unstressed syllables increases, and its difference between (2a) and (2e) is 1089 ms.

Table 7. Korean speakers' average sentence duration with increased syllables (ms)

(ms)		sentence	3 stressed syllables (ratio)	unstressed syllables (ratio)	number of unstressed syllables	duration per unstressed syllable	increased sentence duration
(2)a	ave.	1065	912 (0.86)	153 (0.14)	1	153	
	s.d.	51.2	34.3				
(2)b	ave.	1530	858 (0.56)	672 (0.44)	3	224	465 (44%)
	s.d.	261.7	119.2				
(2)c	ave.	1809	770 (0.43)	1039 (0.57)	4	260	279 (18%)
	s.d.	261.8	60.5				
(2)d	ave.	2105	763 (0.36)	1342 (0.64)	6	224	296 (16%)
	s.d.	218.8	128.5				
(2)e	ave.	2461	795 (0.36)	1666 (0.64)	8	208	356 (17%)
	s.d.	456.4	184.3				

<Table 7> summarizes the duration of the sentences from (2a) to (2e) produced by Korean speakers. The average duration of the sentence (2a) is 1065 ms, and the duration of one unstressed syllable is 153 ms. The sentence (2b) lasts 1530 ms long, and it has two more unstressed syllables than the sentence (2a). The sentence duration difference between (2a) and (2b) is 465 ms (44% increased), and the average duration of each unstressed syllable is 224 ms. There is one more unstressed syllable increased in the sentence (2c). The duration difference between (2b) and (2c) is 279 ms (18% increased), and the average duration of the unstressed syllable is 260 ms. The sentence (2d) has two more unstressed syllables than (2c) and has 296 ms longer duration (16% increased). The average duration per unstressed syllable is 224 ms. The sentence (2e) is 356 ms longer than the sentence (2d) (17% increased), and the average duration per unstressed syllable is 208 ms. The duration of three stressed syllables gradually decreases from the sentence (2a) to (2d), but increases in the sentence (2e). However, the duration of the unstressed syllables gradually increases as the number of the unstressed syllables increases, and the difference in length between the first sentence (three stressed syllables and one unstressed syllable) and the last sentence (three stressed syllables and eight

unstressed syllables) is 1396 ms. According to <Table 6> and <Table 7>, the ratio of the unstressed syllable to the sentence of Korean speakers is higher than that of Americans. It means Korean speakers speak unstressed syllables in the sentence longer than Americans.

The sentences (2a), (2c) and (2e) have three stressed syllables respectively. These three sentences are divided into three parts including one stressed syllable in each part: subject, verb, and object. The sentence (2a) does not have any unstressed syllables between stressed syllables except the last syllable. Each part consists of one content word (stressed syllable) and unstressed syllables in the sentences (2c) and (2e). The duration of syllables is shown in <Table 8>, in which the duration of one unstressed syllable after the verb need in (2e) was measured together with the main verb need.

Table 8. The duration of each syllable in the sentences (2a), (2c), and (2e)

			subject		verb		object	
	(ms)		(1)the	boys	(2)will (be)	need (ing)	(3)some (of their)	money
(2a)	Ave./	Amer		390/52.6		305/80.2		399/43.5
	s.d.	Kor		357/56.8		329/50.7		379/32.9
	t-value			-0.837		0.514		-0.734
	p-value			0.435		0.625		0.490
(2c)	Ave./	Amer	181/10.9	349/80.4	221/15.1	286/49.1	258/25.6	382/19.9
	s.d.	Kor	214/57.9	357/36.5	285/83.4	273/23.5	324/36.1	357/10.8
	t-value		0.441	0.623	0.281	-0.110	2.475	-0.615
	p-value		0.674	0.556	0.248	0.916	0.048*	0.561
(2e)	Ave./	Amer	182/15.9	357/18.2	277/28.5	421/37.9	507/23.3	361/16.2
	/s.d.	Kor	215/58.8	383/26.2	331/56.2	425/20.1	785/39.5	322/30.0
	t-value		0.731	3.827	0.831	2.759	7.503	-2.804
	p-value		0.493	0.09	0.438	0.33	0.000*	0.031*

*p<0.05

The duration of each stressed syllable of Americans is 390 ms, 305 ms, and 399 ms. The duration of each stressed syllable of Koreans in the sentence (2a) is 357ms, 329 ms, and 379 ms. The duration difference in (2a) between Americans and Koreans is not very big. In the sentence (2c), one unstressed syllable added to each stressed syllable. The duration of the unstressed syllables (1), (2), and (3) between the stressed syllables by Americans is 181 ms, 221 ms, and 258 ms, respectively. The duration of the unstressed syllables (1), (2), and (3) between the stressed syllables by Koreans is 214 ms, 285 ms, and 324 ms, respectively. The duration difference of the unstressed syllable *some* between Americans and Koreans is significant ($p=0.048$). In the sentence (2e), the subject is the same as the one in (2c). One

unstressed syllable be added to the unstressed syllable *will*, and two unstressed syllables of *their* added to the unstressed syllable *some*. The duration of the unstressed syllables (1), (2), and (3) between the stressed syllables by Americans is 182 ms, 277 ms, and 507 ms, respectively. The duration of the unstressed syllables (1), (2), and (3) between the stressed syllables by Koreans is 215 ms, 331 ms, 785 ms. The duration difference of the unstressed syllables *some of their* between Americans and Koreans is significant ($p=0.000$). The duration of the unstressed syllables (1), (2), (3) between stressed syllables in (2c) and (2e) is shown in <Figure 2>.

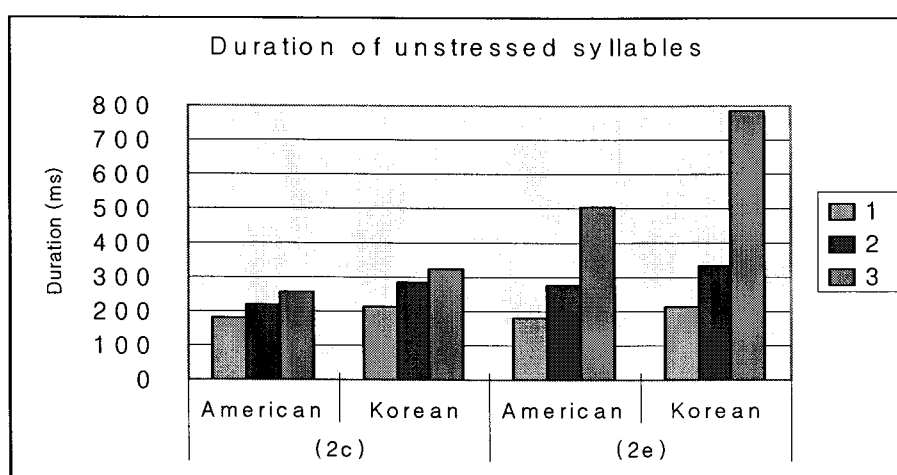


Figure 2. Duration of unstressed syllables between stressed syllables in (2c) and (2e)

In English, content words are stressed and function words are usually not stressed in a sentence. As a stressed-timed language, in English, stressed syllables occur at equal intervals. If there is no unstressed syllables between stressed syllables, stressed syllables will be stretched out longer so as to space them equally. And if there are unstressed syllables between stressed syllables, they will be pronounced faster and reduced in order that speaker can reach the next beat on time (Chun, 2002).

According to <Table 8> and <Figure 2>, in the sentence (2c), both Americans and Koreans produced each stressed syllable without any unstressed syllables with similar duration. In the sentence (2c) one unstressed syllable was added to each stressed syllable, they produced each unstressed syllable without big difference. However, in the sentence (2e), the duration of unstressed syllables (3) is longer than that of (1) and (2). Americans produced unstressed syllables *some of their* 249 ms longer than *some* in (2c), and 230 ms longer than *will be* in the sentence (2e). Koreans produced the unstressed syllables *some of their* 461 ms longer than *some* in (2c), and 454 ms longer than *will be* in the sentence (2e). Even though both Americans and Koreans produced the unstressed syllables *some of their* longer than the other two unstressed

syllables, Koreans pronounced them much longer than Americans. As the number of unstressed syllables increased, the duration by Koreans increased much longer as shown in (3) of (2e).

The result in this experiment shows that the duration of unstressed syllables by Americans increased as the number of unstressed syllables increased. This result does not exactly correspond with the characteristic of English as a stressed-timed language that stressed syllables occur with regular intervals, as presented in Chun (2002). However, it seems that Americans tended to pronounce unstressed syllables faster for the regular intervals of the stressed syllables than Koreans. Koreans produced unstressed syllables and sentences with longer duration when the number of unstressed syllables increased, which means that Koreans were influenced by Korean, syllable-timed language.

4. Conclusion

This study examined English sentence stress and rhythm produced by Korean speakers, compared to those produced by Americans. The subjects read sentences with neutral stress and with emphatic stress, and read sentences with increased unstressed syllables. Stressed words were analyzed with respect to duration, fundamental frequency, and intensity. These three features were related to English sentence stress, but Koreans and Americans had different acoustic characteristics about English sentence stress. When the words were emphasized, both speakers had higher fundamental frequency and intensity of the stressed vowel, and longer duration of the stressed vowel except a few words than when the sentence had neutral stress. However, Korean speakers of English realized the sentence stress with shorter vowel duration and higher F0 than American English speakers when the words had emphatic stress. This was similar to the acoustic characteristics of Mandarin speakers in Chen et al. (2001).

The analysis of the timing of the sentence with increased unstressed syllables showed that both Americans and Koreans produced the sentence with longer duration as the number of unstressed syllables increased. But Koreans had longer duration than Americans. Americans seemed to produce the unstressed syllables between stressed syllables faster for the regular intervals than Koreans. This implies that Koreans will produce unstressed syllables with longer duration as the number of unstressed syllables between stressed syllables increases.

This study reflects that when Koreans produce English, they are influenced by Korean, a syllable-timed language, in which each syllable tends to have the same duration. When the acoustic differences between Americans and Koreans are applied in teaching English pronunciation related to stress and rhythm, and when Korean speakers of English learn the characteristics of English, their English will be more natural and native speech-like.

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