

THESIS

STRESS AND VOWEL REDUCTION BY KOREAN LEARNERS OF ENGLISH

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ABSTRACT

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With regard to teaching a second language, it has been controversial what a language teacher should focus on in developing intelligibility versus native-like production. Having a foreign accent is unavoidable for late second or foreign language learners because it becomes harder to acquire and produce the native-like pronunciation in a second language, essentially because older learners already have a well-established first language, which mediates the acquisition of a second language. A consequence of this mediation is negative transfer from the L1 to L2, which occurs because of phonological system differences between the L1 and L2, influencing language learners on their production of segmental and suprasegmental aspects of pronunciation.

The purpose of this thesis is to examine patterns of vowel reduction in Korean accented English, with the goal of finding pronunciation issues in the English for Korean learners that might be due to transfer effects from an acoustic-phonetic standpoint. In terms of methodology, a corpus linguistics approach is used since the corpus approach enables access to a sufficient amount of digitized recordings of the participants easily and economically. Scripted recorded speech samples from native English and Korean speakers of the Wildcat Corpus which was shared by Ann Bradlow from Northwestern University (Bradlow, n.d.) were used for data analysis. The data analysis will be divided into two parts. One is focused on the duration ratios of the unstressed vowels produced by Korean and English speakers, and the other is focused on the formant values of the unstressed vowels.

Results showed that the duration ratios of the unstressed vowels produced by Korean speakers were bigger than native English speakers, indicating that Korean speakers do not reduce the unstressed vowels as English speakers do. Also, there were discrepancies in the qualities of the unstressed vowels between native Korean and English speakers although the formant values were very similar. Korean speakers tend to assimilate English unstressed vowels into similar vowels in their vowel inventory and produce them as full vowels. Therefore, vowel reduction does not occur by Korean speakers of English in the same way as native English speakers do, consequently it causes Korean accented English.

Based on the literature review related to the hypotheses and the findings of the current study, pedagogical suggestions will be provided regarding suprasegmental instruction that might help Korean learners of English to be aware of spoken English stress patterns focusing on vowel production that strongly relates to the intonation in English.

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TABLE OF CONTENTS

ABSTRACT.....	ii
ACKNOWLEDGEMENTS.....	iv
LIST OF TABLES.....	viii
LIST OF FIGURES.....	ix
INTRODUCTION	1
The Process of Pronunciation Acquisition in Second Language Learning	1
Theories of Pronunciation Acquisition - SLM and PAM	2
Having Accents and Identity Issues	3
Intelligibility vs. Nativeness: What ELLs Should Focus On	4
Debate Regarding Suprasegmental Influences on Intelligibility	6
Main Focus of the Thesis	7
LITERATURE REVIEW	9
Comparison of General Phonological Systems of Korean and English.....	9
English and Korean Vowel Qualities	9
English Word Stress and Intonation.....	11
Korean Word Stress and Intonation	14
The Negative Transfer/Error Tendencies	16
Error Tendencies in English Vowel Production by Native Korean Speakers.....	17
Importance of Learning Suprasegmental to Improve Intelligibility	21
RESEARCH APPROACH AND METHODOLOGY.....	23
Hypotheses	23

Method	23
Participants	23
Spontaneous Speech Corpus vs. Lab Speech	24
Procedures	25
RESULTS	30
Duration analysis	30
Formant analysis	36
DISCUSSION	57
Pedagogical Implication	60
CONCLUSION	63
REFERENCES	66

LIST OF TABLES

Table 1. Vowel Chart for English and Korean	9
Table 2. Average Vowel Formant Frequencies Produced by Native English and Korean Speakers	10
Table 3. 11 Selected Two-Syllable Words Including Two Vowels.....	27
Table 4. The Comparison of Average Duration Ratio (Unstressed vowel÷Stressed vowel).....	31
Table 5. The Averages of F1 and F2 for the Stressed Vowel /ʌ/ and Unstressed Vowel /ə/ Produced by Korean and English Male Speakers.	47
Table 6. The P-values for F1 and F2 Produced by Korean and English Male Speakers	47
Table 7. The Averages of F1 and F2 for the Stressed Vowel /ʌ/ and Unstressed Vowel /ə/ Produced by Korean and English Female Speakers.	49
Table 8. The P-values for F1 and F2 Produced by Korean and English Female Speakers	49

LIST OF FIGURES

Figure 1. A Screenshot of a Korean Male's Data (Stressed vowel)	28
Figure 2. A Screenshot of a Korean Male's Data (Unstressed vowel)	28
Figure 3. The Non-Compound Words Duration Ratio Average	33
Figure 4. The Compound Words Duration Ratio Average	34
Figure 5. The Scatter Plot for /ə/ produced by Korean (blue) and English (orange) Male Speakers	38
Figure 6. The Boxplot for /ə/ F1 Values produced by Korean (blue) and English (orange) Male Speakers	39
Figure 7. The Boxplot for /ə/ F2 Values produced by Korean (blue) and English (orange) Male Speakers	40
Figure 8. The Scatter Plot for /ə/ produced by Korean (blue) and English (orange) Female Speakers	42
Figure 9. The Boxplot for /ə/ F1 Values produced by Korean (blue) and English (orange) Female Speakers	43
Figure 10. The Boxplot for /ə/ F2 Values produced by Korean (blue) and English (orange) Female Speakers	44
Figure 11. The Comparison of Stressed Vowel /ʌ/ and Reduced Vowel Productions in the Word Color by Male speakers	46
Figure 12. The Comparison of Stressed Vowel /ʌ/ and Reduced Vowel /ə/ Productions in the Word Color by Female Speakers	48

Figure 13. The Comparison of Unstressed Vowel /ɪ/ Productions in the Words Pointed and Dessert by Male Speakers	51
Figure 14. The Comparison of Unstressed Vowel /ɪ/ Productions in the Words Pointed and Dessert by Female Speakers	52
Figure 15. The Comparison of Unstressed Vowel /ʌ/ Productions in the Words Wristwatch and Racecar by Male Speakers	54
Figure 16. The Comparison of Unstressed Vowel /ʌ/ Productions in the Words Wristwatch and Racecar by Female Speakers.....	55

INTRODUCTION

The Process of Pronunciation Acquisition in Second Language Learning

Since English is a lingua franca, English is actually spoken by non-native speakers more than native speakers. Statistically, there are 369.9 million people who speak English as their L1 and 978.2 million people who use English as their L2 (Eberhard et al., 2021). Therefore, it is understandable that English is often taught by non-native English teachers, and many English language learners (ELLs) have their own accents that are influenced by their first languages depending on the learning environment. There are several factors that interfere with second language learners' pronunciation acquisition, for example, the learners' age, first language transfer, learners' experience learning second language, and curriculum issues regarding pronunciation.

It is well known that as people get older, it becomes harder to acquire and produce native-like pronunciation in a second language. The reason is that physical changes in the brain influence learning a variety of aspects in a new language system (Flege, 1987; Patkowski, 1990), and this phenomenon is called the *Critical Period* (Penfield & Roberts, 1959). Selinker (1972) also said that pronunciation accuracy is difficult to acquire after puberty owing to *phonetic fossilisation*. Werker and Tees (2002) also indicated that there is a benefit for early learners to learn pronunciation in an L2 because of *Perceptual Reorganization*. In the experiment, researchers recognized that a 6-month old infant whose parents spoke English could distinguish two different sounds in Hindi. On the other hand, another baby who was 4 months older did not show reaction to the different sounds. Thus, it is thought to be better to learn a second language earlier in learners' lives.

English language learners' (ELLs) language knowledge is also influenced by their first language, especially in late acquisition. For example, those who are learning a foreign language might struggle with pronouncing phonemes or ordering grammar in a second language even though they have learned the target language for a long time, especially if the language features of their mother tongue and the second language are very different from each other. Unfortunately, nonnative accents can cause the experience of stigma and discrimination.

Theories of Pronunciation Acquisition - SLM and PAM

According to Best et al. (1988), the perceptual categories can be based on the native language phonology system, called the Perceptual Assimilation Model (*PAM*). In other words, when adults hear unfamiliar sounds from other languages, they try to find similar sounds from their L1 perceptual system. Thus, it is difficult for adults to hear and distinguish two different sounds since unfamiliar sounds tend to be assimilated to a single perceptual category in the adults' L1. For instance, when native English speakers hear the dental /t̪/ or retroflex /ɖ/ in Hindi, they tend to perceive the two different sounds as a single category /t/ in English. However, it might be easier for native English speakers to distinguish two different foreign sounds such as dental /d̪/ and uvular /ʁ/ in French. The reason is that they will recognize them as two different categories such as /d/ and /r/ in English respectively.

While Best's (1988) PAM explained that the perceptual process is deeply related to listeners' prior experience and their L1, Flege's Speech Learning Model (*SLM*) (1995) is more focused on L2 phonetic learning and the ability to distinguish the L2 from L1. SLM indicates that the level of difficulty perceiving different sounds varies depending on a degree of similarity between the L1 and L2. Thus, if an L2 sound is very similar to an L1 sound, it might be difficult for the language learners to perceive the differences, whereas if an L2 sound is very different

from any L1 sound, it might be easier for language learners to recognize the differences. Also, SLM suggested that if a language learner is able to distinguish two different sounds, the production of two different sounds pronounced by the language learner becomes better over time. For instance, Flege (1987) found that native English speakers tend to perceive and produce the French vowel /y/ as native French speakers do because there is no category for /y/ in English, but they tend not to distinguish and produce the French vowel /u/ since it is similar to English /u/.

As previous studies showed, pronunciation acquisition affects the phonology system of the native language. Even though the ability to perceive various sounds between the L1 and L2 does not always correspond to producing L2 pronunciation accurately, they are influenced by the differences of phonology systems between the L1 and L2. Therefore, it is noteworthy that being aware of differences of phonology systems between the L1 and L2 is important for learners to improve their listening and speaking skills in their L2.

Having Accents and Identity Issues

Gluszek and Dovidio (2010) researched to what extent stigmatization and problems in communication individuals with nonnative accents experience, the effects of the experience of stigma and communication problems associated with nonnative accents on social belonging in the United States. They found that people who have nonnative accents perceived bias and difficulties in communicating, especially they tended to perceive a higher level of stigmatization when they rated their accents as stronger. The participants also reported that there is less discrimination if they have a European accent rather than an Asian or Latino accent because of more favorable perceptions of European accents. In addition, participants with nonnative accents had a lower sense of belonging in their community than the participants with regional and

standard accents. The results show how foreign accents affect social perception through communication in English.

However, having an accent is not necessarily a problem. Morgan (2010) mentioned that learners can acquire an identity and become someone somewhat different from one's self in their native language through the language learning process. In other words, second language learning involves the acquisition of a second identity, so having an accent is natural and allows learners to express where they come from and who they are (Brown, 2000, p.182). Moreover, prior study suggested that pronunciation issues or foreign accents by second language learners can be improved depending on the length of residence in the L2 country, the quality of L2 learners' interactions with native speakers of the target languages, and their attitudes to accept a new language and culture (Newton & Nation, 2009). Thus, it is an important role for instructors to give learners chances to know about accent diversity and help learners to overcome negative feelings about having foreign accents.

Additionally, if a listener is familiar with an accent by a particular speaker or has a lot of experience interacting with the speaker, the intelligibility of the speaker's pronunciation will be more understandable and intelligible for the listener (Newton & Nation, 2009). Therefore, instructors also need to encourage students to be patient and keep interacting with native English speakers as much as they can even though the first interaction may have many recasts and repairs.

Intelligibility vs. Nativeness: What ELLs Should Focus On

For these reasons, and from a World English point of view, it is more important to pursue intelligibility and fluency in the second language rather than to acquire native-like pronunciation because World English takes account of the diversity of English language regarding

pronunciation and is used as an international communication (Deterding, 2012). However, to improve intelligibility and fluency in the second language, it is necessary to understand how foreign accents produced by language learners are different from the nature of English pronunciation such as manner of articulation, stress and intonation patterns produced by native speakers of English. If learners do not know the most general sounds, which are considered as a standard pronunciation that native English speakers such as American or British actually produce, ELLs might have problems with listening in English. Therefore, it is crucial for language learners to be aware of the differences in the basic phonological systems between the L1 and L2 and also the variations existing in the L2.

Today, more attention is being paid to learning to speak fluent English in South Korea (Cho, 2004). For instance, many universities and companies in Korea require students to show their communication skills in English. In fact, the number of test takers who took the Test of English for International Communication (TOEIC) Speaking significantly increased from 15,000 in 2007 to 260,000 in 2012 (Korea TOEIC Council, 2013). Based on the TOEIC Speaking proficiency level descriptors, the test takers' proficiency levels are evaluated by 8 scale scores from 1 (low proficiency) to 8 (high proficiency). To get the highest score, the test takers are required to speak English with complex grammar structures, accurate and precise vocabulary, highly intelligible pronunciation such as intonation and stress at all times, but the descriptors do not specifically mention native-like requirements (TOEIC Speaking and Writing Tests Score Overview (For Organizations), 2021).

Other English proficiency tests such as the Test of English as a Foreign Language (TOEFL) and International English Language Testing System (IELTS) also evaluate the test taker's speaking skills based on the use of a range of grammar structures and appropriate

vocabulary without hesitancy, mispronunciations or intonation errors, but they do not specifically mention native-like pronunciation just as the TOEIC does not. Even though most Korean students have been taught English from elementary school and spend a lot of time on it, it is still hard to be competent in English in terms of speaking skills. The reason might be because little emphasis has been put on the two languages' different phonological systems, and the teaching of pronunciation is generally integrated as a part of a course instead of being taught stand-alone.

Debate Regarding Suprasegmental Influences on Intelligibility

To utilize the target language competently, it is necessary to learn not only intelligible pronunciation of each phoneme but also the prosodic system in the target language (Derwing et al., 1998; Levis & Grant, 2003). Thus, it is worth paying attention to the debate about segmental versus suprasegmental focus and the effectiveness of instruction related to both aspects in teaching pronunciation. Several studies pointed out that consonant errors accounted as segmental issues outweigh vowel errors accounted as suprasegmental issues (Fayer & Krasinski, 1987; Koster & Koet, 1993). For instance, English prosody is less problematic than segmentals for Dutch speakers since the prosodic features of Dutch are similar to English, so instruction focused on segmental aspects of pronunciations would be useful for Dutch learners of English to improve their intelligibility in English (Koster & Koet, 1993).

On the other hand, according to Derwing et al. (1998), suprasegmental pronunciation instruction for adult L2 learners is more effective and advantageous to improve learners' fluency, accentedness, and comprehensibility in English rather than segmental instruction. In the study, the researchers asked ESL teachers to rate adult learners' speech samples. Only the group of students who had received suprasegmental instruction received significantly better scores on the

second measurement and showed a great improvement. It is thought that intelligibility tends to be evaluated by the use of stress patterns and intonation in natural speech in the target language rather than production of each phoneme.

Beyond that, many other studies also emphasized that suprasegmental instruction is useful to improve oral communication skills such as accentedness and comprehensibility (Avery & Ehrlich, 1992; Kang, 2010; Morley, 1991). In this respect, this thesis took notice of the suprasegmental aspects of pronunciation, then investigated the differences between Korean and English language, and the main pronunciation issues that Korean learners of English have focusing on vowel production that affects stress and intonation patterns in English.

Main Focus of the Thesis

While it is inevitable to have an accent in a second language, intelligibility can still be improved with learning experience such as through great quality of interaction with native English speakers and also effective instruction. To educate and support language learners who need to learn more than one language to communicate with others in a global environment, it is important to be aware of how second language accented speech works and its causes because it could lead learners to acquire and develop the second language more successfully. In other words, it is helpful to think about pronunciation issues encountered by second language learners and to see what kinds of the pedagogical applications are suggested for them.

To focus on the Korean learners of English, early research found that most Korean students struggle with pronunciation of certain consonants, most notably, /l/ and /r/, dental fricatives /θ/ and /ð/, and alveolar affricates /dʒ/ and /tʃ/ in English. Also, Korean students have pronunciation issues with vowels, stress, and intonation (Avery & Ehrlich, 1992; Sereno et al., 2016). However, the suprasegmental issues are less understood than segmental ones. For

example, Korean speakers appear to make less clear distinctions of intensity between stressed and unstressed vowels and duration (length) of vowels than native English speakers do (Lee et al., 2006). In other words, Korean speakers have a difficult time perceiving and producing the difference between tense and lax vowels in their own language, so this tendency might affect the acquisition of stress in English since English word stress varies depending on the weight of the vowel that is in a syllable (Guion, 2005; Sereno et al., 2016). Because of these differences, many Korean English language learners have difficulty in acquiring English stress and intonation features.

Therefore, connected speech processes associated with stress and intonation patterns will be examined from previous research and a corpus analysis with the goal of finding out tendencies that Korean learners of English produce, which can cause intelligibility problems. Particularly, the current study will prove the findings of the study conducted by Lee et al. (2006) by analyzing existing data from the Wildcat Corpus' Korean section of spoken English.

LITERATURE REVIEW

Comparison of General Phonological Systems of Korean and English

English and Korean Vowel Qualities

To shed light on the vowels in English and Korean languages, Table 1, which is an English and Korean vowel table created based on the criterion of IPA vowel chart, is shown below. The English and Korean vowels were classified by referring to the descriptions of the vowels by Yavaş (2011) and Brown and Yeon (2015) respectively. In general, the monophthongs that are pronounced in real speech in English are 12, whereas only 7 are included in Korean speech. Also, the Korean vowel chart does not have /ə/ in their inventory. That is to say, Korean learners of English might have difficulty perceiving and producing vowels in English and may assimilate several different English vowels into a single category based on PAM, one of the pronunciation acquisition theories mentioned previously.

Table 1.

Vowel Chart for English and Korean

English				Korean			
	Front	Central	Back		Front	Central	Back
Close	i		u	Close	i	ɨ	u
	ɪ		ʊ				
Close-mid	e		o	Close-mid			o
		ə					
Open-mid	ɛ		ɔ	Open-mid	ɛ		
		ʌ				ʌ	
Open	æ		ɑ	Open			ɑ

English vowels are differentiated by the locations and widths of the formant frequencies (Yavaş, 2011). In other words, formant values vary depending on vowel qualities. Specifically, as stated by Johnson (2011), the frequency of the first formant (F1) is determined by the height of the tongue, and high frequency F1 means the tongue is located in a low position. Conversely, low frequency F1 implies the tongue is located in a high position. The frequency of the second formant (F2) is related to the front and back movement of the tongue, and front vowels tend to be indicated by much higher F2 than back vowels.

Table 2.

Average Vowel Formant Frequencies Produced by Native English and Korean Speakers

English					Korean				
Vowel	Male		Female		Vowel	Male		Female	
	F1	F2	F1	F2		F1	F2	F1	F2
i	270	2300	300	2800	i	235	2184	217	2774
ɪ	400	2000	430	2500	ɛ	489	1926	581	2373
e	469	2082	521	2536	α	804	1314	1060	1594
ə	500	1500	-	-	ɨ	311	1360	333	1619
o	498	1127	528	1206	Λ	521	904	660	1183
ɛ	530	1850	600	2350	u	253	689	268	652
æ	660	1700	860	2050	o	318	691	337	687
α	730	1100	850	1200					
ɔ	570	850	590	900					
ʊ	440	1000	470	1150					
u	300	850	370	950					
Λ	640	1200	760	1400					
ʌ	490	1350	500	1650					

Table 2 is based on the data of formant frequencies produced by English and Korean speakers (Brown & Yeon, 2015; Yang, 1996; Yavaş, 2011). Since formant values are measured for stressed vowels in general, and there are a lot of variations in production of the unstressed vowel /ə/, the estimated formant values for /ə/ calculated by Ladefoged and Johnson (2014) are used in this study. In the study, the researchers explain that the formant frequencies vary depending on the length and shape of the vocal tract, and the resonant frequency is defined by the following formula:

$$F_n = \frac{(2n - 1) \times c}{4L}$$

where n indicates the number of formants (e.g. $n = 1, 2, 3$ means $F1, F2$, and $F3$), and c indicates the speed of sound, L indicates the length of the vocal tract. One of the researchers, Peter Ladefoged's vocal tract was 17.5cm long, and the speed of sound was 35,000. Thus, $F1$ is estimated to be $35,000 \div (4 \times 17.5) = 500$ Hz, and $F2$ is estimated to be $3 \times 35,000 \div (4 \times 17.5) = 1500$ Hz. Another researcher, Keith Johnson's vocal tract was about 16 cm long, and $F1$ and $F2$ were estimated to be 547 Hz and 1641 Hz respectively. Thus, it is thought that the estimated formant values for the unstressed vowel /ə/ are around 500~547 Hz and 1500~1641 Hz.

In order to see if the English vowel qualities produced by Korean speakers affect vowel reduction, the formant values will be analyzed. Through the comparison of the formant values, it will be examined how the production of the English unstressed vowel /ə/ by Korean speakers is different from the production by English speakers.

English Word Stress and Intonation

According to Derwing and Munro (2015), word stress in English is important since it refers to the prosodic characteristics of duration, intensity, and pitch. The stressed syllables are generally pronounced longer, louder, and higher pitched than unstressed syllables, whereas the

unstressed syllable such as a syllable including the unstressed vowel /ə/ is pronounced shorter and reduced rather than being pronounced as a full vowel. In addition, the placement of stress changes the lexical categories: for example, the word *record* is pronounced /'rekəɪd/ when it is used as noun, but the stress moves on to the second syllable and is pronounced /rɪ'kɔ:ɪd/ when it is verb. At the sentence level, the word stress tends to be put on a particular word where the speaker wants to put emphasis. For example,

Question: Which house is JOAN'S? (Capital letters are the prominent word in the sentence)

Answer 1: Here is the BLUE house.

Answer 2: Here is the blue HOUSE.

(Derwing & Munro, 2015, p.59)

Answer 1 implies that the speaker is looking at many houses and the blue color characterizes Joan's house, whereas Answer 2 implies that the speaker is looking at a few blue objects and does not really emphasize what the questioner is seeking. Moreover, English is a stress-timed language, so it is helpful to learn the English rhythmic patterns at word and sentence levels to improve intelligibility in English because it helps listeners to comprehend syntactic structures of the utterances (Derwing & Munro, 2015).

However, the stress patterns in English are highly variable since English has been developed through borrowing from other languages (Celce-Murcia et al., 2010; Finegan, 2015; Yavaş, 2011). Even though word stress in English does not have fixed rules, it does show some patterns. In most cases, English stress is placed at the penultimate syllable which precedes the final syllable (ult), for example, the stress for the word *computer* is located at /pju/ [kəm.pju.ɾər] except in loanwords such as *cigarette* and *mayonnaise* (Yavaş, 2011, p. 157). If the penult is

unstressable, that is, contains a short vowel without coda, then the stress moves to the left next heavy syllable.

The English word stress in compound words tends to be located at the first element (Yavas, 2011). For example, this is seen in compound words consisting of two nouns such as *phónecard*, *máitchbox*, *téapot*, and *póstman*. Moreover, the compound words consisting of adjective and noun such as *whíte house*, verb and noun such as *stóp watch*, and particle/adverb and noun such as *óverdose* and *únderwear* receive the stress on their initial position except in place names such as *Lake Érie*, *Mount Sínai*, and *Great Brítain* (Yavas, 2011, p. 168). Also, the stressed syllables are pronounced longer than unstressed syllables.

However, the English stress patterns of compound words are also changeable depending on semantic properties of the compounds. In the case of compound words, the word stress will be put on the constituent that has the more important meaning. Although many compound words that are created by the combination of two nouns are left-prominent, and the English stress tends to be put on their first element, several researchers found that the stress patterns and pitch realizations for compound words have great variation from their investigation (Kunter, 2011; Plag, 2006; Sabine Arndt-Lappe, 2011; Yavaş, 2011). Beyond that, as reported by Morrill (2012), prior studies found that unstressed vowels can be lengthened when they bear a phrasal pitch accent. For example, the second words in the phrases tend to be pronounced longer than second components in the compound words such as *Red Sox* (compound) and *red socks* (phrase), *softball* (compound) and *soft ball* (phrase), and *Whitecaps* (compound) and *white caps* (phrase) (Cambier-Langeveld, 2000; Sluijter, 1995; Turk & White, 1999).

In terms of intonation in English, it varies depending on discourse contexts. In accordance with Celce-Murcia et al. (2010), the variation of intonation can convey more

meanings such as stating facts, expressing emotions, and showing uncertainty than without it (p. 221). Basically, a variety of questions such as yes/no questions, tag questions, open-choice alternative questions, and information-seeking questions except Wh-Questions are produced with a rising pitch. On the other hand, statements, commands, and enthusiasm which represent “definiteness,” “assurance” and “completion” are pronounced with falling contour in American English (Yavaş, 2011, pp. 172-177).

Statements such as:

(4a) Spinach is a vegetable.

Wh-questions (questions that start with a wh- word such as what, which, where):

(9) Which way did she go?

In yes–no questions (typical order, or with statement order) such as:

(11a) Is this a joke?

(11b) This is a joke?

Certain tag questions that signal uncertainty, such as:

(16) She usually comes at ten, doesn't she?

Open-choice alternative questions, such as:

(15) Would you like a paper or magazine? (something to read?)

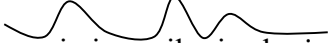
(Yavaş, 2011, pp. 173-176)

Korean Word Stress and Intonation

In contrast to English, Korean is considered a fixed-stress and syllable-timed language. However, according to Brown and Yeon (2015), the stress patterns in Korean are controversial. As reported by Lee (1996), Korean has word-level stress, and that stress generally tends to be put on the first syllable such as 사랑 ['sa.laŋ] *love*, 학교 ['hak.kjo] *school*, 사다리 ['sa.ta.li] *ladder*


in a variety of Korean words. However, when the word has three or more than three syllables and also the word initial syllables consist of consonant and vowel (CV) followed by a syllable consisting of consonant, vowel, and consonant (CVC), the stress is located on the second syllable as in 자동차 [tɛa.ˈtoŋ.teʰa] *car* and 고속도로 [ko.ˈsok.to.lo] *motorway* (p. 42).

On the other hand, other scholars argue that Korean has accents and tones in regard to prosodic units but does not have word-level stress. For example, previous studies explained that Korean prosody is based on a tone pattern associated with an accentual phrase, whereas English prosody is based on stress accents associated with a lexical word (Guion, 2005; Lee et al., 2006). For instance, Jun (1998) explained that the Seoul dialect, which is recognized as a standard accent in Korean, has the tonal patterns Low-High-Low-High (LHLH) or High-High-Low-High (HHLH), and the initial tone is determined Low (L) or High (H) tone depending on what the initial syllable starts with. If the initial syllable starts with an aspirated consonant or a tense consonant/vowel, it becomes High tone. If not, it is determined as Low tone. For example,

a.  na-nin jəŋa-ril miwəh-ejo 나는 영아를 미워해요

I-TOP Younga-ACC hate-ENDING

'I hate Younga': {na-nin} {jəŋa-ril} {miwəh-ejo}

b.  jəŋmi-nin jəŋa-ril miwəh-ejo 영미는 영아를 미워해요

Youngmi-TOP Younga-ACC hate-ENDING

'Youngmi hates Younga': {jəŋmi-nin} {jəŋa-ril} {miwəh-ejo}

(Jun, 1998, p. 195)

As the previous studies showed, suprasegmental aspects in Korean are strongly related to a syllable, not a single vowel. In spite of this disagreement or lack of consensus, it is apparent that Korean does not follow the exact same rules in terms of stress that English does since

Korean is not a stress-timed language, so there is no heavy syllable in a word and vowel reduction also does not occur.

However, intonation in Korean shares some similarities with English. Typically, falling intonation is used for statements such as assuring information and requests (or suggestions) in Korean. Rising intonation is used for all types of interrogative sentences such as seeking agreement and asking questions in Korean, while Wh-questions in English are uttered with falling intonation (Byon, 2009).

The Negative Transfer/Error Tendencies

As we looked at the general phonological system in English and Korean above, English and Korean have different properties with respect to syllables and suprasegmentals, especially the length variation in vowel production. The rhythm of the English language is created depending on the variation in syllable duration and loudness because English is a stress-timed language. Also, stress-timing affects the duration of the stressed and unstressed vowels, and consequently vowel reduction occurs. On the other hand, the rhythm of the Korean language, which is a syllable-timed language like Spanish, French, Italian, Turkish, and Mandarin, is not generated by stress but the recurrences of syllables. In other words, syllable-timed languages lack the vowel reduction (Yavaş, 2011, p.22).

Han et al. (2011) also pointed out that Korean does not have reduced vowels such as /ə/ as English does, so it makes it difficult for Korean learners of English to produce phonetic variants of English, especially vowel reduction (p. 549). As the study conducted by Han et al. reported (2011), native English speakers produced vowel reduction with a /ə/ and a barred-*i*, and they reduced the duration of the vowel more when the vowel is in the initial position than final position. However, Korean learners of English, especially those who do not have any residence

experience in English speaking countries, tended not to reduce the length of the reduced vowels and tried to pronounce them as a full vowel as they do in L1 production. They also tended to pronounce the English unstressed vowel /ə/ with higher F1 than English speakers. That is to say, the vowel qualities that Korean produced were not the same as the vowel qualities that native speakers of English produced.

Error Tendencies in English Vowel Production by Native Korean Speakers

Guion (2005) conducted two experiments to examine the production and the perception of English stress placement by early and late age of Korean-English bilinguals. For the two experiments, a total of 30 participants consisting of 10 native English speakers, 10 early Korean-English bilinguals, and 10 late Korean-English bilinguals participated. In Experiment 1, they were asked to pronounce 40 two-syllable nonwords written by phonemic transcription. The nonwords used in the experiment had different 4 syllabic structures such as CVV-CVCC (*ber tɪst*, *tu: kɪps*, *taɪ gept*), CV-CVCC (*dɛ kɪps*, *nɪ gept*, *kɪ mɪnz*), CV-CVC (*nɪ lɛt*, *dɛ sɪn*, *sɛ lɪn*), and CV-CVVC (*nɪ li:t*, *dɛ gu:t*, *bɪ teɪs*). They were framed in two types of sentences such as “I’d like to ~” which is a verb frame and “I’d like a ~” which is a noun frame.

Results indicated, all three groups of participants tended to put the word stress on the initial syllable when the nonwords were framed in a noun frame and also contained a long vowel. Specifically, the stress patterns produced by native English speakers were more consistent than late Korean-English bilinguals. That is to say, the stress patterns produced by native English speakers are greatly influenced and varied by the vowel length compared to late Korean-English bilinguals. The researcher also found that the late Korean-English bilinguals tended to put the word stress in the final position when a long vowel was in the final syllable and also in the noun

frame. For instance, they put the stress on the second syllable when the nonword consists of CV-CVVC rather than CV-CVC.

In Experiment 2, the participants were asked to listen to pre-recorded phrases that contained two different stress patterns of nonwords such as initial and final stress, and to select one which is the most like a native English sentence. For example, the participants listened to the sentence “I’d like a [‘ber tɪst]” where the stress was put on the first syllable in the nonword and “I’d like a [ber ‘tɪst]” where the stress is put on the second syllable. They listened to the target nonword twice. Once was in a noun frame and once was in a verb frame.

Consequently, all three groups of participants showed similar results in the perception experiment compared to the production experiment. However, the group of native English speakers much preferred to select the nonwords that contained an initial stressed syllable in the noun frame than the verb frame for all 4 types of syllabic structures. On the other hand, the early bilinguals preferred initial stress for 3 types of syllabic structures such as CVV-CVCC, CV-CVCC and CV-CVVC, and the late bilinguals preferred initial stress only for 2 types of syllabic structures such as CV-CVC and CV-CVVC, meaning the Korean-English bilinguals had more variations in their results.

In conclusion, the researchers pointed out that the stress patterns that the native English speakers produced were overall more consistent and robust than early and late Korean-English speakers. Moreover, the early Korean-English bilinguals showed more native-like responses in the production experiment than the late Korean-English bilinguals. Interestingly, there were no significant differences among the three groups of participants in the perception experiment, so the researcher suggested that bilinguals tend to perform the English stress placement better in perception than production.

In the study conducted by Lee et al. (2006), the researchers investigated the production of unstressed English vowels produced by Korean and Japanese learners. The researchers hypothesized Korean speakers might have trouble in differentiating the vowel duration, intensity, and reduction since Korean does not have these phonetic features. They also hypothesized Japanese speakers have difficulty differentiating the vowel intensity and reduction since Japanese does not have the language properties and also is a mora-timed language.

In the experiment, 20 Korean and 20 Japanese speakers participated. To focus on the Korean speakers, the 10 early Korean-English bilinguals and the 10 late Korean-English bilinguals were asked to pronounce 19 English words that consisted of various stress positions. For example, the words such as *agent* ['eɪdʒənt], *giraffe* [dʒə' ræf], *origin* ['ɔ: rɪdʒɪn] and *kangaroo* [kæŋgə' ru] were listed. The researchers measured the values of duration, fundamental frequency, intensity for stressed and unstressed vowels, and vowel quality for unstressed vowels.

In the comparison of the duration for the unstressed vowels, the duration ratios of unstressed vowels produced by Korean speakers were larger than native English speakers and Japanese speakers although the durational differences between stressed and unstressed by Korean speakers were not significant. For the fundamental frequency, the ratio showed no significant differences between native English speakers and both Korean and Japanese speakers. That is, they concluded that the L1 background and age of acquisition do not affect the fundamental frequency of vowels, and Korean and Japanese speakers were able to produce differences in fundamental frequency between unstressed and stressed English vowels. Regarding intensity, the ratios were calculated by subtracting the value of unstressed vowels from stressed vowels, and they concluded that both early and late Korean bilinguals have much

smaller intensity than native English speakers, whereas Japanese speakers showed native-like production.

For the vowel quality, Korean bilinguals produced unstressed vowels with many variations. In particular, the production of unstressed vowels by early Korean bilinguals was similar to [ɪ]. The reason is thought that Korean language has a high-central vowel which is [ɪ], so they tend to assimilate the unstressed high-front vowel [i] in English into [ɪ] instead of trying to develop native-like production. However, Japanese produced more native-like vowel formants, and the reason was conjectured to be that there is no similar unstressed vowel [ɪ] in Japanese, so they developed a more native-like production. In general, the formant values for late Korean and Japanese speakers were more dispersed than early Korean and Japanese speakers compared to native English speakers. This indicates that vowel qualities for unstressed vowels that were produced by late non-native speakers were not accurate.

As the results of the two studies showed, many Korean learners of English have difficulty in acquiring stress and differentiating between stressed and unstressed vowels in English because of the differences between Korean and English suprasegmental aspects of pronunciation and negative transfer based on perceived similarities with the native language. Also, it tends to be more challenging for learners who started to learn English late in their life.

According to Strange and Shafer (2008), specific patterns that exist in each language are hard to acquire since the selective perception routines (SPRs) for the native language are more robust and efficient than the SPRs for the second language. In other words, the cognitive process of phonetic perception in the L1 is faster and more automatic than in the L2. Nonetheless, if language learners are young and do not have problems with their auditory sense, they will have less interference from their L1 phonological systems in developing the process of selective

perception, and have more chances to improve various pronunciation errors under optimal listening conditions (pp. 169-170).

Importance of Learning Suprasegmental to Improve Intelligibility

Since Korean learners of English, especially late learners, have more issues with production and perception of English vowels because of the different phonology system, it is helpful for them to be aware of the different pronunciation rules between the L1 and L2 at the early stage of the language learning process to increase their intelligibility in English.

Consequently, learners can consciously correct suprasegmental errors in English themselves and reduce the errors. Several prior studies also recommended that it is desirable to learn about linking in English, which is also called connected speech and which happens in natural utterances because it affects performance in listening comprehension. Linking is not a unique phenomena, but also it does not always occur in every language, so it might be difficult for language learners to understand how it is pronounced and heard if they do not have a chance to learn the linking process in English (Mees et al., 2017; Rost, 2011).

According to Wong et al. (2021), connected speech that is produced by native English speakers make non-native speakers of English misinterpret input and interfere with listening comprehension, especially in authentic situations. In the study, researchers conducted an experiment to investigate what kind of perceptual errors non-native speakers make when they listen to connected speech in English. The participants were 60 Hong Kong undergraduate native Cantonese students who had been learning English as a second language since Kindergarten. Their language proficiency levels were between modest and competent, which are similar levels to 5.58 and 5.68 in International English Language Testing (IELTS). The participants were asked

to listen to various speech items and type what they heard. Basically, they had two chances to reply to the items and revise their answer if they needed to.

As a result, the researchers found a range of error types with phonological errors such as consonant errors, vowel errors, changes in syllable numbers, and misordering, and also error types with lexical and syntactic perceptual errors such as misperception of the stress pattern and word boundaries. Particularly, the most frequent errors were vowel and consonant errors. For instance, the participants perceived *they've* as *they*, *married you* as *married Jine*, *might rain* as *my ring*, *won't* as *want*, *these* as *this*, *this year is* as *this is*, and *I suppose so* as *expert said* or *iceberg*. Several researchers mentioned that those perceptual errors are common in an ESL context, and occur more in connected speech than non-connected speech. Furthermore, there is more variation regarding the types of errors with the results by non-native speakers compared to native speakers (Bond, 1999; Wong et al., 2021). These observations show that it is crucial and worthwhile to teach suprasegmental aspects of pronunciation to help language learners' comprehensibility and intelligibility in the target language.

RESEARCH APPROACH AND METHODOLOGY

From the literature review section, we learned how intentional focus on suprasegmentals is important to improve learners' speaking and listening skills in English. In this study, the English vowel production by Korean speakers of English will be the focus since the vowel production is strongly related to the suprasegmental aspects of pronunciation in English.

Hypotheses

1. The duration ratio for unstressed vowels produced by Korean speakers will be bigger than English native speakers' since Korean speakers do not reduce their unstressed vowels as much as the English speakers do.
2. In terms of vowel quality, formant value for the target vowel /ə/ will be produced differently by native English speakers and Korean speakers of English since the Korean vowel system does not have /ə/ which is a mid central vowel.

Method

Participants

To investigate the relationship between suprasegmental aspects of pronunciation and the occurrence of foreign accents, especially production of English vowels by native Korean speakers, a corpus linguistic approach is used since the corpus approach enables the researchers to access a large/adequate amount of digitized recordings collected by various background information of the participants easily and economically. The corpus used in this study is the Wildcat Corpus's Korean and English section of spoken English (Bradlow, n.d.).

The Wildcat Corpus contains scripted and unscripted recorded speech samples from each of 84 speakers: 24 native speakers of English consisting of 12 males and 12 females who are

between 18 and 33 years old (average = 20.5) recruited from the Northwestern University community and 60 non-native speakers of English consisting of 36 males and 24 females who are between 22 and 34 years old (average = 26.2). The non-native speakers of English were mostly recruited from the Northwestern University International Summer Institute (n = 43), an intensive English language and acculturation program for incoming Ph.D. students at the university. Moreover, 17 out of 28 native speakers of Korean were recruited from the broader Northwestern community.

For current study, the recorded files that were collected were based on lab speech by 10 male and 10 female native speakers of English and 10 male and 10 female Korean speakers of English and were randomly selected from the scripted corpus. The participants were asked to read 60 sentences (see Appendix A) in the corpus in English, and their utterances were recorded.

Spontaneous Speech Corpus vs. Lab Speech

Phonetic data is typically used to examine the acoustic phonetics and articulatory phonetics. The main purpose of these investigations based on phonetics is to identify phonological categories and structures varying in speech productions (Lieberman, 2019, p. 92). To conduct data analysis regarding acoustic phonetics, spontaneous speech corpus and lab speech can be used. Both spontaneous speech corpus data and lab speech are the collection of speech recordings and facilitate researchers to have quantitative data. In the spontaneous speech corpus, the speech interactions are recorded and transcribed later, whereas in the lab speech, speakers are asked to read aloud scripts, and their utterances are recorded.

Xu (2010) pointed out that the spontaneous speech corpus contains more rich emotions and prosody, so it is more natural and communicative, while lab speech is over planned, over clear, and monotonous. However, it is difficult to get the factors related to the specific

phenomenon that researchers want to look at in spontaneous speech corpus data since the speech data is not fully controlled. Therefore, Xu (2010) mentioned that lab speech based on experimental control should not be marginalized because it allows us to focus on observing the target features and making the research process easier (p. 334).

As stated by Liberman (2019), the advanced electronic and digital technologies lead a cultural shift in the study of speech and language and empirical analysis with large quantities of data (p. 103). As a result, it has become easier for researchers to access a variety of speech corpora, test empirical hypotheses, and get reliable and valid results. Therefore, in this study, the Wildcat Corpus was utilized to test our empirical hypotheses. In particular, the scripted speech data is used because it is necessary to have a number of recorded data for the same words to compare the differences of English vowel productions such as duration and formant values by native English and Korean speakers. Unscripted speech data from the spontaneous speech corpus is unpredictable since different words are going to be spoken by different speakers. Therefore, it is not really ideal to collect the acoustic phonetic data using the unscripted speech corpus.

Procedures

For data analysis, Praat which is a free computer software for speech analysis in phonetics was used to make the acoustic data into visual data allowing us to get objective results such as the vowel durations and formant values. In the current study, duration analysis and formant analysis will be conducted based on the data measured using Praat.

First of all, 11 words were selected for two analyses from 60 sentences (see Table 3). It was determined that the selected words should be two syllables and include two vowels to compare the duration ratio of English vowels between stressed and unstressed vowels and also to analyze formant values for unstressed vowels produced by native English speakers and Korean

speakers of English. Also, each word needed to contain a tonic syllable since a tonic syllable shows the contrast between stressed and unstressed syllables in the word apparent and clear. A tonic syllable is the most important syllable, and the pitch in the word shows a steep drop when the unit of speech begins.

Next, each sentence including the selected words was extracted as wav files. The locations of the selected words in each sentence and the stressed and unstressed vowels in the word were tagged in Tiers and saved as TextGrid files. Particularly, the location of the word was labeled in Tier 1, and the locations of the stressed and unstressed vowels were labeled in Tier 2. Finally, an excel file including all information of formant value and duration value for stressed and unstressed vowels was created by using the script function in Praat.

Based on the data collections, the duration and formant were analyzed to verify our hypotheses. In the duration analysis, the duration ratio of unstressed vowels was calculated, and the proportion of unstressed vowels produced by Korean and English speakers was compared. Specifically, as we learned from the literature review section, compound words typically have great variation on English stress patterns, so the duration ratios were analyzed by separating into the analysis of the compound words and non-compound words. Moreover, the R-studio which is a software that helps us to get statistical information such as t-value and p-value was used to investigate what factors affect the duration of the unstressed vowels. For the formant analysis, scatter plots and box plots were used to look at the deviation between the productions of an unstressed vowel, especially English /ə/ produced by Korean and English speakers.

Table 3.

11 Selected Two-Syllable Words Including Two Vowels

Words	Stressed Vowel	Unstressed Vowel	Sentence
pointed ['pɔɪntɪd]	/ɔɪ/	/ɪ/	1. He pointed at the cents.
people ['pi:pəl]	/i/	/ə/	4. Many people like to start the day with a cup of coffee.
*wristwatch ['rɪstwɑ:tʃ]	/ɪ/	/ɑ/	12. A wristwatch is used to tell the time.
color ['kʌlər]	/ʌ/	/ə/	17. The color of a lemon is yellow.
*football ['fʊtbɔ:l]	/ʊ/	/ɔ/	23. Football is a dangerous sport.
*racecar [reɪskɑ:r]	/eɪ/	/ɑ/	30. A racecar can go very fast.
quarter ['kwɔ:rtər]	/ɔ/	/ə/	32. A quarter is worth twenty-five cents.
dessert [dɪ'zɜ:rt]	/ɜ/	/ɪ/	38. For dessert, he had apple pie.
pigeon ['pɪdʒən]	/ɪ/	/ə/	54. A pigeon is a kind of bird.
about [ə'baʊt]	/aʊ/	/ə/	55. He talked about the dinner.
parents ['perənt]	/ɛ/	/ə/	57. My parents, sister and I are a family.

Notes. * indicates compound words.

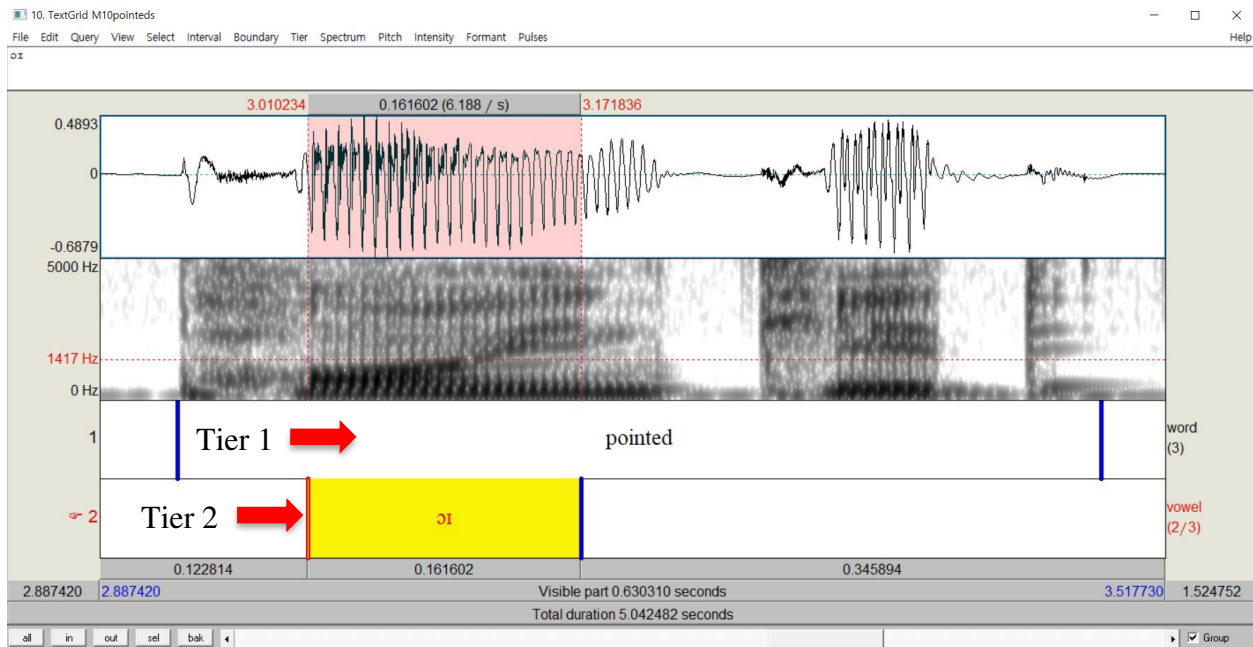


Figure 1. A Screenshot of a Korean Male's Data (Stressed vowel)

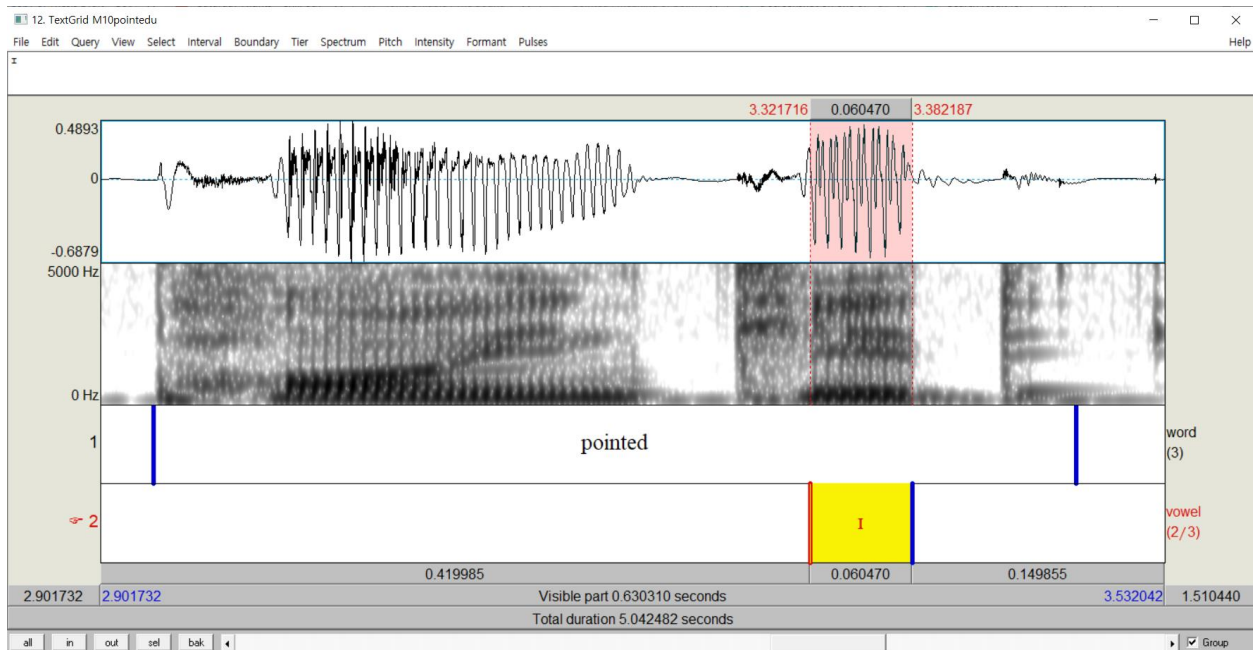


Figure 2. A Screenshot of a Korean Male's Data (Unstressed vowel)

Figure 1 is a screenshot that was taken when the wav file of the word *pointed* synchronized with TextGrid file for stressed vowel [ɔɪ]. Also, Figure 2 shows the wav file for the word *pointed* synchronized with a TextGrid file for unstressed vowel [ɪ]. As explained in the

procedure, Tier 1 indicates the word, and Tier 2 indicates the location of the vowel. The 11 words and the stressed and unstressed vowels in each of the words were tagged and saved going through the same procedures. Above the Tier 1, it displays a spectrogram which contains the information of pitch, intensity, and formant values of the audio file. In general, vowels are the most sonorous sounds, so they are marked darker compared to other sounds in the spectrogram, meaning strong in intensity. On the top of the spectrogram, there is a waveform which shows the frequency and amplitude. Likewise spectrogram, a waveform for a vowel sounds also shows a bigger wave than other sounds because vowels are louder than other sounds. Since the stressed vowel in the word *pointed* is a diphthong, the movement of the sounds from [ɔ] to [ɪ] were detected by the spectrogram.

RESULTS

Duration analysis

By using the duration values extracted from the script in Praat, the duration ratio between stressed and unstressed vowels was calculated following the same formula used in Lee et al.

(2006):

$$\text{Duration ratio} = \frac{\text{Duration of unstressed vowel}}{\text{Duration of stressed vowel}}$$

The ratios were calculated to compare the duration for target vowels accurately regardless of the entire duration for each vowel. In terms of the proportion size, if the division value of the unstressed vowel by the stressed is equal to 1, both vowels have the same duration, so there is no reduction. If the division is < 1, the unstressed vowel is shorter than the stressed vowel, meaning there is reduction. If the division is > 1, then the unstressed vowel is longer than the stressed one, meaning there is no reduction. Furthermore, if the division is over 2, it means the unstressed vowels produced were much longer than stressed vowels.

Moreover, to ensure the reliability and validity of the data, a linear mixed effects analysis was conducted since it allows us to see the relationship between a dependent variable and other independent variables depending on the fixed and random effects. The function used to do all the mixed effect analyses was lmer from the lme4 (Bates & Sarkar, 2007) package in R (R Core Team 2013). In the duration analysis, the dependent variable is the vowel duration ratio, and the independent factors are gender and the first language of the speakers. Through this analysis, it is possible to see whether or not there are any effects on being Korean speakers and native English speakers on the dependent variable. The random variables in this study are the subjects (speakers) and the words.

The average proportion for all the duration values regardless of L1, gender, words, and speakers was 1.13. Table 4 shows the average duration ratios divided by native language, gender and word. In general, the ratio produced by Korean speakers was larger than English speakers. Specifically, the average duration proportion for the Korean male speakers was 1.2725, while the average for the English male speakers was 1.0093. Similar to the male speakers, the average duration proportion for the Korean female speakers was 1.2716, while the average for the English female speakers was 0.9612. This means that Korean speakers tended not to reduce the unstressed vowels, at least in terms of duration, whereas English speakers tended to reduce unstressed vowels more than Korean speakers.

Table 4.

The Comparison of Average Duration Ratios (Unstressed vowel ÷ Stressed vowel)

	Male		Female	
	Korean	English	Korean	English
pointed	0.5737	0.4502	0.5178	0.5770
people	2.2704	1.4837	2.1902	1.3453
*wristwatch	1.6128	1.5949	1.4723	1.1729
color	1.0535	0.8481	1.3931	1.0586
*football	2.4717	2.6283	2.3612	2.2545
*racecar	1.1524	0.6743	1.2461	0.6809
quarter	1.1838	0.7712	1.4325	0.7078
dessert	0.8894	0.4240	0.6306	0.4938
pigeon	1.1648	0.9077	1.1264	1.0931
about	0.4893	0.2611	0.5552	0.2218
parents	1.1354	1.0588	1.0621	0.9676
Average	1.2725	1.0093	1.2716	0.9612

Notes. * indicates compound words.

The first statistical model¹ based on the dataset containing all of the duration values for the 11 English words produced by male and female Korean and English speakers was operated to determine the effects of gender. The results showed there was no main effect of gender on the duration ratio for all words, with the males duration ratios being 0.04810 longer than the females ratios ($t(440) = 0.697$, $p = 0.486084$). Given the lack of statistical significance, moving forward, gender will not be further analyzed. There was, however, a significant effect of native language, where the duration ratios of Korean speakers were on average, 0.31038 longer than the durations of native English speakers ($t(440) = 4.498$, $p < 0.05$)²

Typically, compound words have variations on English stress patterns, the duration ratios were analyzed by separating into the analysis of the compound words and non-compound words. In respect of word types, the average duration ratios of unstressed vowels in the non-compound words was 0.95, while the average ratio for the compound words was 1.61 regardless of speakers' L1s. Statistically, there was no significant effect of word types in the average duration ratio between Korean and English speakers ($t(440) = -1.938$, $p = 0.08317$)³. Despite the apparent lack of significance, we start with the analysis of non-compound words because there was a discrepancy in the average ratios for the non-compound and compound words regardless of speakers' L1s.

¹ The function in R is: `lmer(proportion~language*gender+(1|speaker)+(1|word),allduration)`

² The function in R is: `lmer(proportion~language+(1|speaker)+(1|word),allduration)`

³ The function in R is: `lmer(proportion~language*types+(1|speaker)+(1|word),wordtypes)`

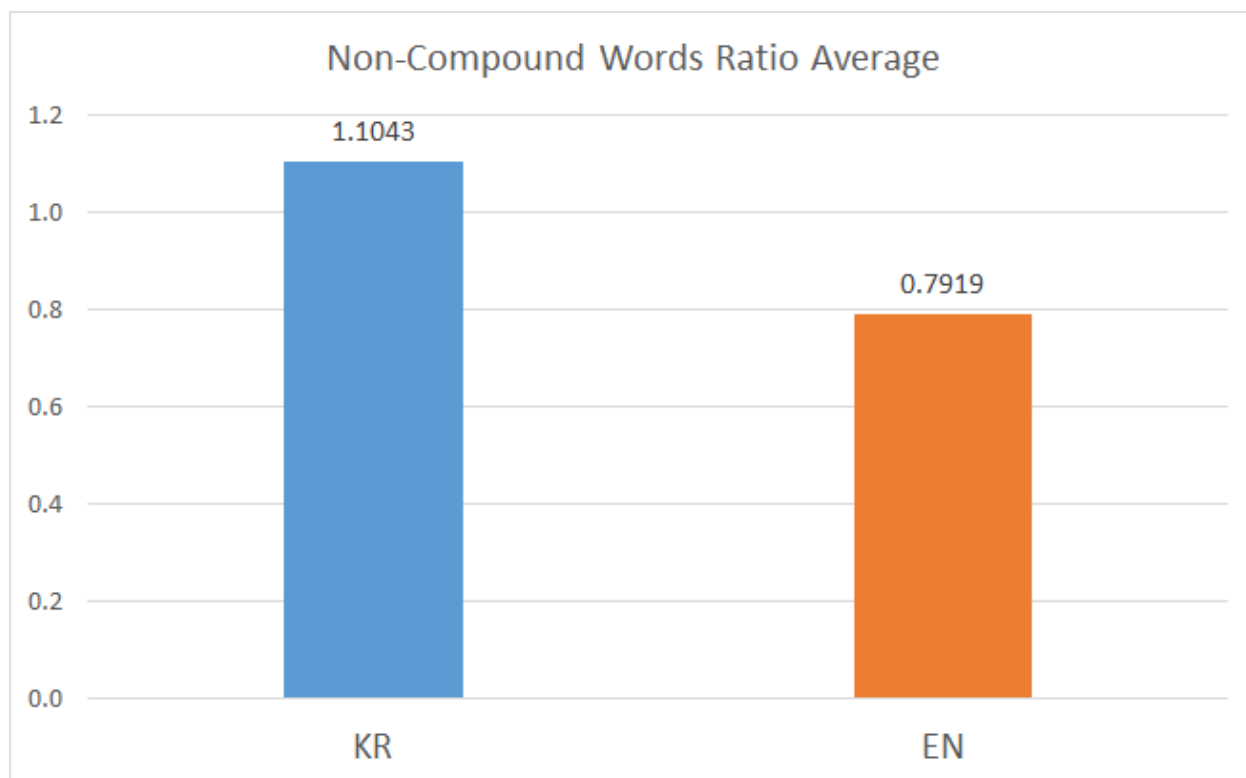


Figure 3. The Non-Compound Words Duration Ratio Averages

Model⁴ with language as the only variable was run. The results revealed there was a significant effect of language, with the duration ratios by Korean being 0.31240 longer than English speakers ($t(320) = 6.466$, $p < 0.05$) in case of non-compound words. It means that if the speaker's native language is Korean, the duration ratios for the unstressed vowels were consistently bigger than English speakers' regardless of their gender, likely because Korean speakers do not reduce unstressed vowels as much as English speakers do.

⁴ The function in R is: `lmer(proportion~language+(1|speaker)+(1|word),noncompound)`

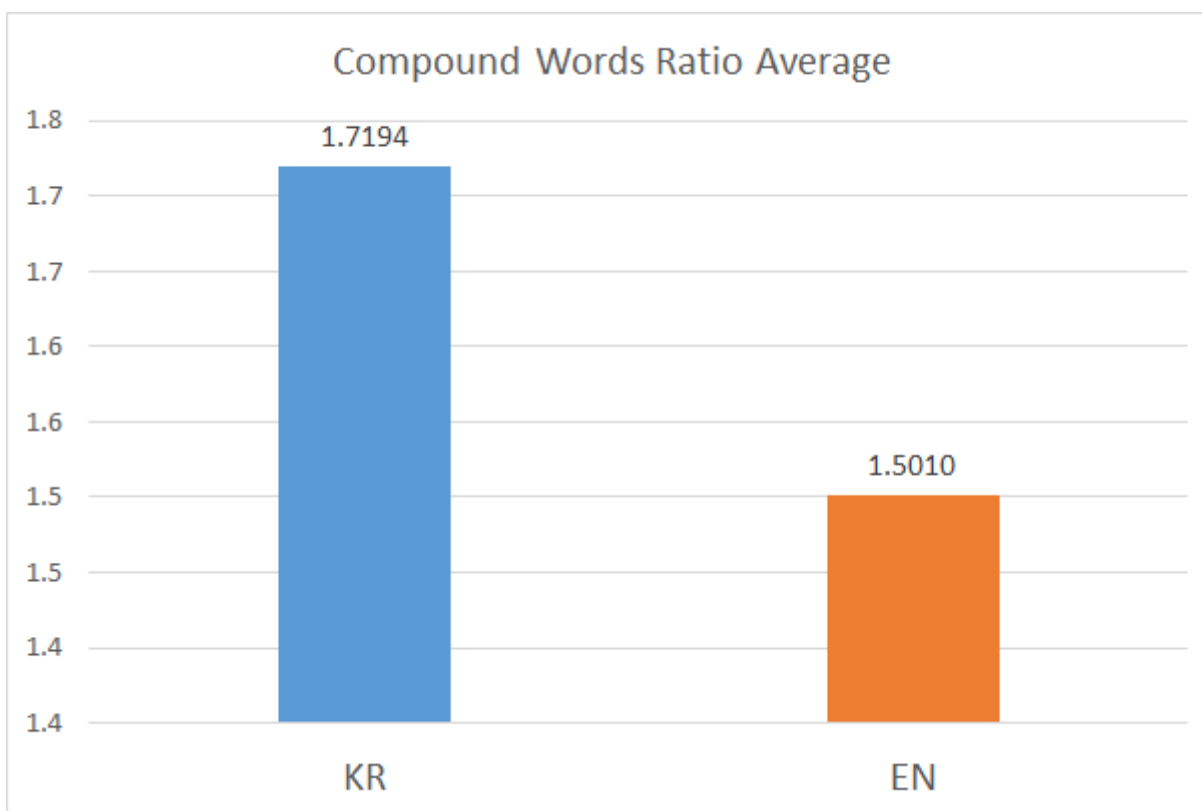


Figure 4. The Compound Words Duration Ratio Averages

Figure 4 is the graph showing the average duration ratio for only the compound words which were *wristwatch*, *football* and *racecar* from our 11 selected words. Based on Figure 4, it can be concluded that the unstressed vowels were produced longer than stressed vowels in the case of compound words regardless of L1 and gender since the average ratios were bigger than 1. However, the results of a model⁵ with language as the only variable for the three compound words showed that there were statistically no significant effects on the duration ratio for the compound words, with the duration ratios by Korean being 0.2184 longer than the duration ratios by English speakers ($t(120) = 1.641$, $p = 0.1091$).

The reason for such results is probably because there is great variation in vowel reduction by English and Korean speakers regardless of their gender. Going back to Table 4, it is clear that

⁵ The function in R is: `lmer(proportion~language+(1|speaker)+(1|word),compound)`

the duration ratios for the compound word *wristwatch* produced by all speakers were over 1. This means that the speakers, regardless of their first language, pronounced the unstressed vowel [ɑ:] in the second syllable longer than the stressed vowel [ɪ] in the first syllable although the English dictionary explains that the stressed symbol is put on the first syllable and transcribed as /'ɪstwa:tʃ/ (Longman Dictionary of Contemporary English, 2021). This result indicates that even native English speakers tend not to reduce the duration of the unstressed vowel in the compound word *wristwatch*.

In addition, the duration ratios for the compound word *football* produced by all speakers were also over 2. This indicates that the unstressed vowel [ɔ:] in the second syllable was produced as much longer than the stressed vowel [ʊ] in the first syllable even though the English dictionary demonstrates that the stress symbol needed to be put on the first syllable in the word *football* and is described as /'fʊtbɔ:l/ (Longman Dictionary of Contemporary English, 2021). The results can be interpreted that English stressed vowels are not always produced longer than unstressed vowels in case of compound words even by native English speakers.

However, it is difficult to generalize that unstressed vowels in compound words are always produced longer than stressed vowels by all speakers. For instance, the duration ratio for the compound word *racecar* by native English speakers showed vowel reduction for the unstressed vowel [ɑ:] in the second syllable, while Korean speakers did not reduce based on the results in Table 4. In other words, the stressed vowel [eɪ] in the first syllable was actually produced longer by English speakers as the English dictionary described it: /'ɪɪs kɑ:ɪ/ (Longman Dictionary of Contemporary English, 2021). Therefore, the English stress patterns for compound words have great variation, and the results correspond to the findings of many previous studies as discussed in the literature review section.

Formant analysis

The data extracted using the script in Praat also contains the formant values for stressed and unstressed vowels. The first and the second formants, F1 and F2, respectively, are particularly important, as they convey information about vowel quality (Ladefoged & Johnson, 2014). Formants were measured at seven equidistant time points from the total duration of the unstressed vowel. Then the values located at the middle of the vowel duration were used in the analysis because it is thought to be the most stable part of the time points. In order to examine the English unstressed vowel qualities produced by Korean speakers, the formant values for English /ə/ included in the words *people*, *color*, *quarter*, *pigeon*, *about*, and *parents* were used in this formant analysis.

The average F1 and F2 for /ə/ productions in the six words regardless of speakers' L1s and gender were 492.65 Hz and 1444.07 Hz respectively. To examine the effect of the L1 on formant values, a linear mixed model analysis was also carried out. In the formant analysis, the dependent variable is the formant values, F1 and F2, and the independent factors are the first language of the speakers and gender. The random variables are subjects (speakers) and words. Then we investigate if there are any effects from being Korean speakers and native English speakers on the dependent variable.

Model⁶ with language as the only variable was run. As a result, when the speakers' L1 is Korean, there is an effect on the F1 values, with the F1 values by Korean being 70.05 Hz larger than the F1 by English, ($t(240) = 2.698$, $p = 0.0104$). Although the statistical significance is not very big, it is still considered that the F1 values of Korean speakers are different than of English speakers since the p-value indicates under 0.05. For the F2 values, there was also an effect when

⁶ The function in R is: `lmer(F1~language+(1|speaker)+(1|word),formantschwas)`

the L1 is Korean, with the F2 values by Korean being 136.417 Hz smaller than the F2 by English speakers ($t(240) = -2.154, p = 0.0377$)⁷. Additionally, there was a significant effect on formant value F1 ($t(240) = -3.783, p = 0.000565$)⁸ and F2 ($t(240) = -4.734, p < 0.05$)⁹ depending on gender, with male F1 and F2 being different from female values by 98.82 Hz and -309.38 Hz, respectively.

Given that there was a significant gender effect, the formant analysis will be divided by gender. This effect was expected, as it is well-known that there are anatomical differences associated with gender. As stated by Johnson et al. (1993), the productions of the English vowels vary depending on speakers because of the differences of individual characteristics in vocal tract anatomy, such as tongue size, vocal folds and vocal tract length, which influences an individual's articulatory patterns, and these are correlated with gender (p. 711). Overall, the data from males were more clearly condensed, so it is easier to compare the differences of /ə/ quality between Korean and English males than the data from females.

The average F1 and F2 by Korean male speakers were 443.8 Hz and 1266.3 Hz, while the averages by English male speakers were 408.7 Hz and 1328.3 Hz. There was an effect of language on F1 ($t(120) = 2.612, p = 0.0177$)¹⁰ and on F2 ($t(120) = -2.11, p = 0.0491$)¹¹.

According to the tube model of vowel production (Johnson, 2011), F1 corresponds to the height of the tongue and mandible in terms of articulation, and lower frequency of F1 means the tongue is high in the vowel tract, closer to the palate and alveolar ridge; F2 corresponds to the front/back movement of the tongue, and higher frequency of F2 means the tongue is placed more fronted

⁷ The function in R is: `lmer(F2~language+(1|speaker)+(1|word),formantschwas)`

⁸ The function in R is: `lmer(F1~language*gender+(1|speaker)+(1|word),formantschwas)`

⁹ The function in R is: `lmer(F2~language*gender+(1|speaker)+(1|word),formantschwas)`

¹⁰ The function in R is: `lmer(F1~language+(1|speaker)+(1|word),formantschwamale)`

¹¹ The function in R is: `lmer(F2~language+(1|speaker)+(1|word),formantschwamale)`

towards the alveolar ridge, while lower F2 frequency means the tongue is placed more backwards towards the velum. Hence, the average F1 and F2 frequencies by English male speakers inferred the positions of tongue were slightly higher and more fronted when English male speakers pronounced /ə/ than Korean male speakers.

To see what individual productions look like depending on L1, scatter plots were created. Figures 5 below show the formant values of English /ə/ by native Korean and English male speakers in a $F2 \times F1$ scatter plot.

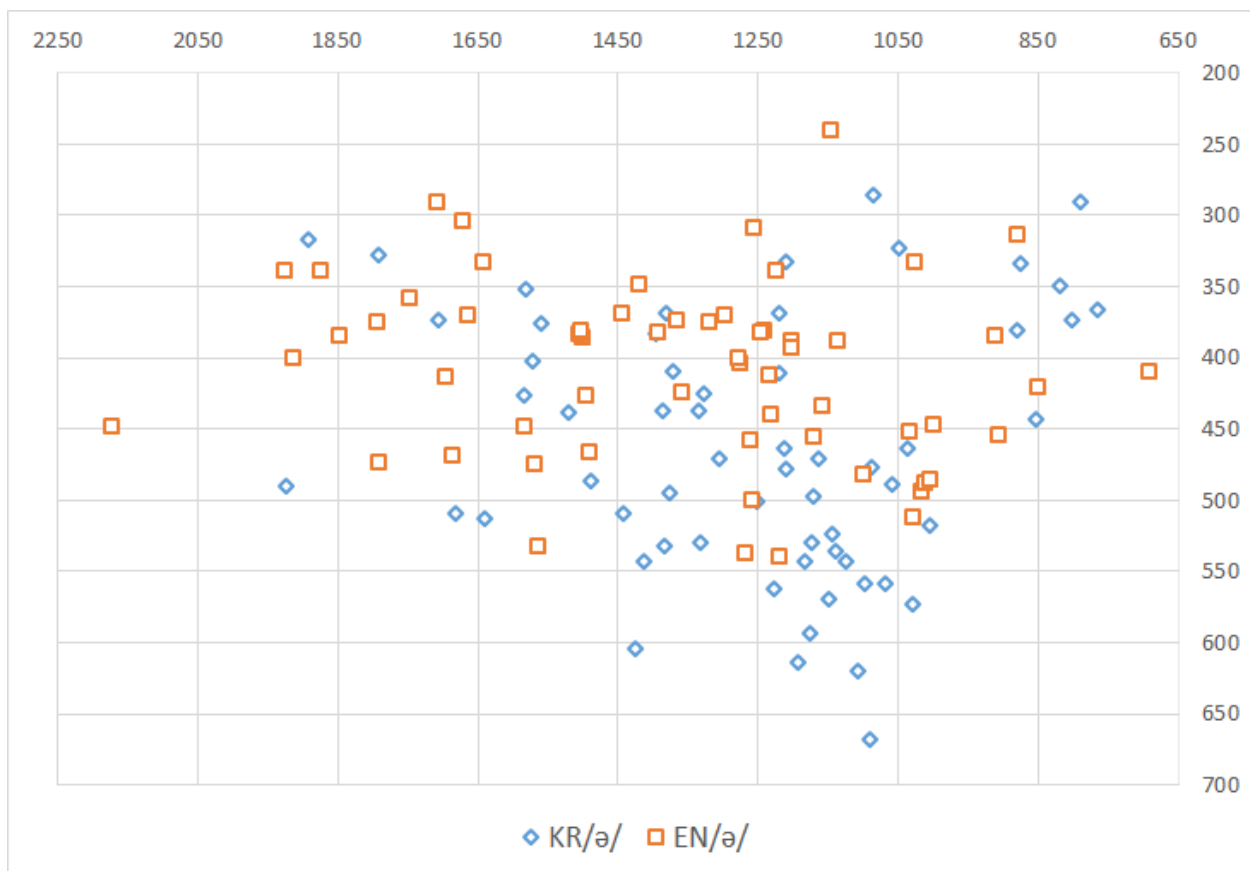


Figure 5. The Scatter Plot for /ə/ Produced by Korean (blue) and English (orange) Male Speakers.

As Figures 5 show, Korean male speakers tend to produce English reduced vowels as a lower and more back vowel, while the English native speakers tend to pronounce it as a mid

central vowel, despite considerable overlap. More specifically, there is a dot cluster indicating the /ə/ production by Korean male towards the bottom right of the graph (F1:550~700 Hz, F2:1000~1450 Hz).

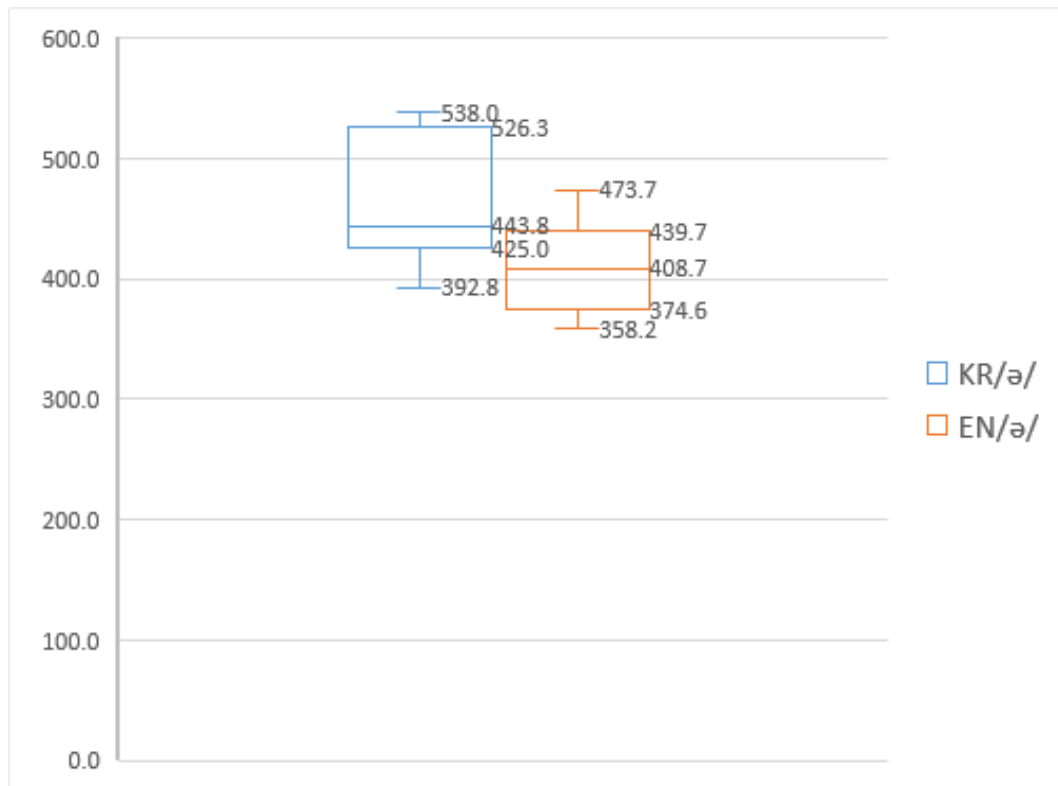


Figure 6. The Boxplot for /ə/ F1 Values Produced by Korean (blue) and English (orange) Male Speakers.

A series of boxplots¹² was created to investigate the variation of the /ə/ production in more detail. Referring to Figure 6, F1 boxplot for Koreans is much higher visually than the boxplot for English males, and that there seems to be very little overlap between them, which is consistent with the statistical significant difference presented earlier. At least 75% of English male speakers produced /ə/ with the F1 value 374.6 Hz or higher than that, and Korean male

¹² Boxplots show the five-number summary of a set of data such as the minimum score, first (lower) quartile, median, third (upper) quartile, and maximum score (McLeod, 2019, July 19)

speakers produced /ə/ with the F1 value 425.0 Hz or higher than that. Specifically, the boxplot by Korean male speakers is positively more skewed, whereas the boxplot by English male speakers is not skewed very much. This means that the data by Korean male speakers mainly consists of higher values than the median, and there were more variations, but the data by English male speakers was more consistent and had less variations. Also, the interquartile difference for Korean male speakers is 36.2 bigger than for English male speakers, which shows how much more variable F1 for Korean males is.

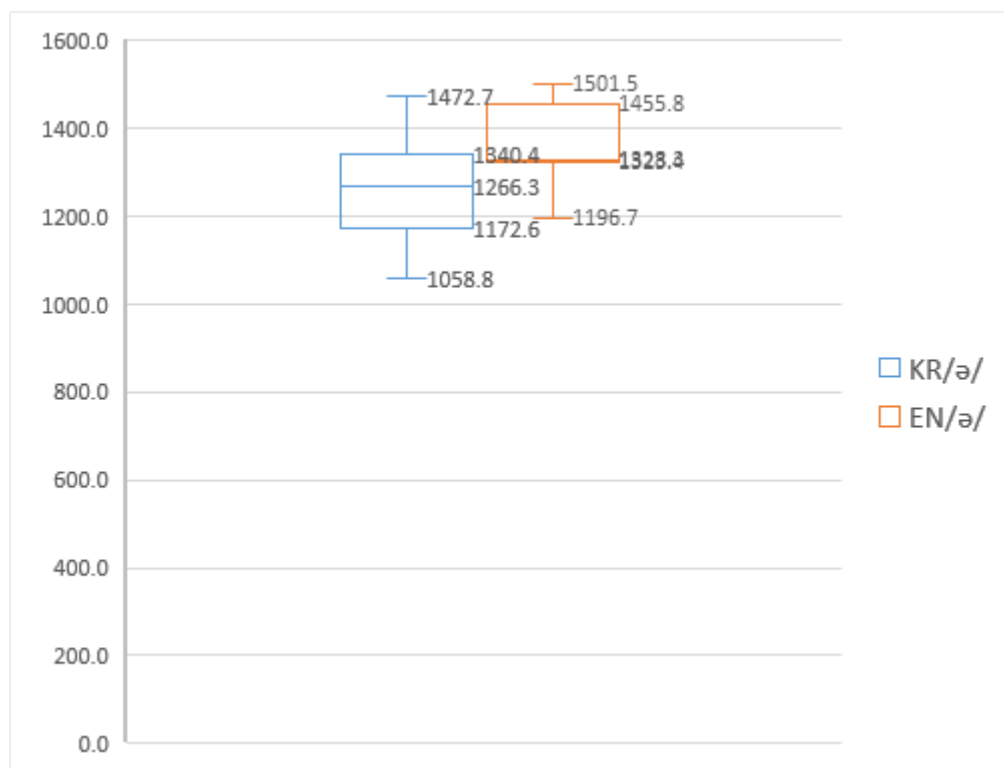


Figure 7. The Boxplot for /ə/ F2 Values Produced by Korean (blue) and English (orange) Male Speakers.

As Figure 7 shows, the F2 boxplot for Koreans is slightly lower visually than the boxplot for English males, and that there seems to be very little overlap between them, which is consistent with the statistical significant difference presented earlier. At least 75 % of English male speakers produced /ə/ with the F2 value 1323.4 Hz or higher than that, and Korean male

speakers produced /ə/ with the F2 value 1172.6 Hz or more than that. In particular, the boxplot by English male speakers was shown to have an extremely positive skew, and the values of median and lower quartile were overlapped. Also, the interquartile difference for Korean male speakers is 35.4 bigger than for English male speakers, which shows how much more variable F2 for Korean males is.

Next, the results of the formant analysis for female speakers are presented, similar to the formant analysis of the Korean and English male speakers. The average F1 and F2 by Korean female speakers were 615.3 Hz and 1542.5 Hz respectively. The averages by English female speakers were 507.7 Hz and 1721.4 Hz, which were a bit higher and more fronted than Korean female speakers. There was a slight significant effect of language on F1 ($t(120) = 2.809$, $p = 0.0116$)¹³ and on F2 ($t(120) = -2.181$, $p = 0.0427$)¹⁴.

To examine what individual productions look like depending on L1, scatter plots were created for the female data as well. Figures 8, below shows the formant values of English /ə/ by native Korean and English female speakers in a $F2 \times F1$ scatter plot.

¹³ The function in R is: `lmer(F1~language+(1|speaker)+(1|word),formantschwafemale)`

¹⁴ The function in R is: `lmer(F2~language+(1|speaker)+(1|word),formantschwafemale)`

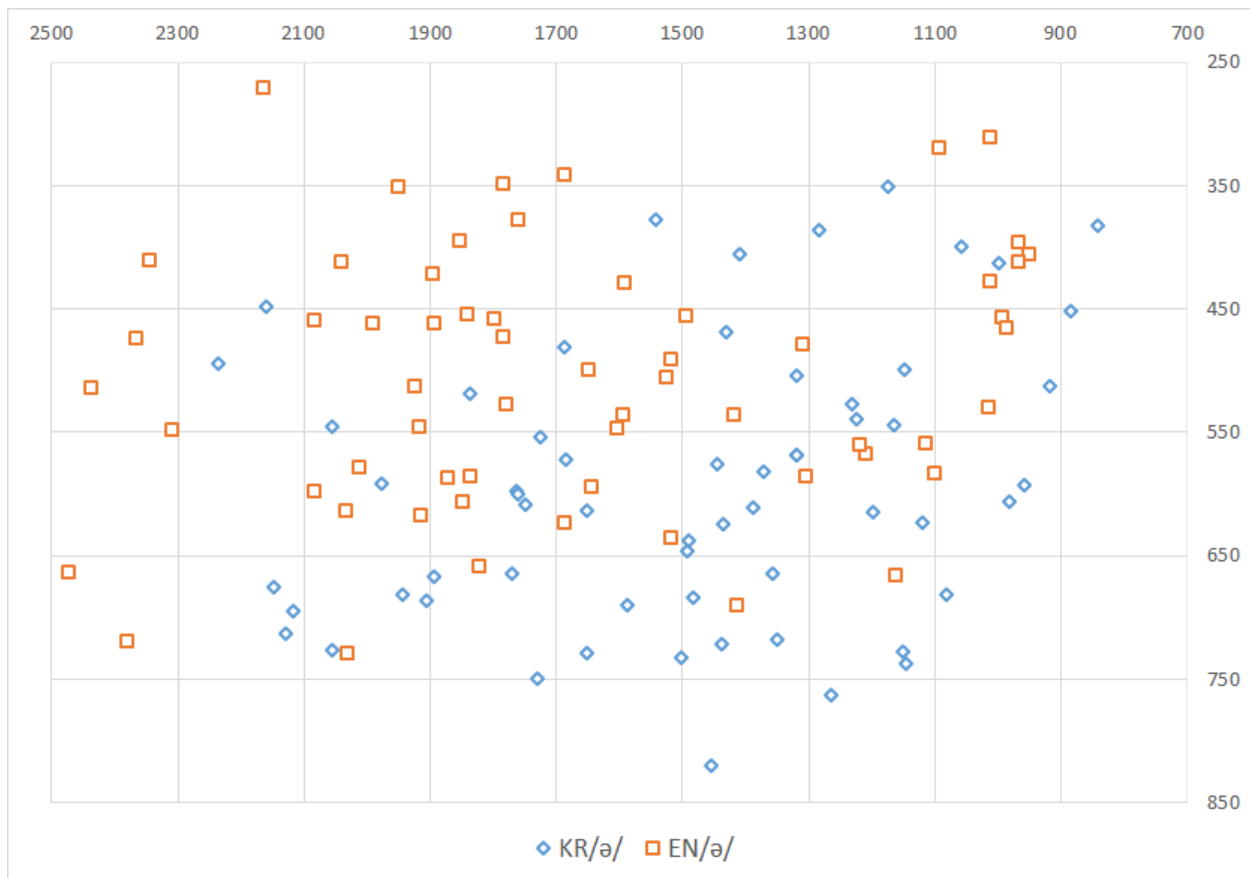


Figure 8. The Scatter Plot for /ə/ Produced by Korean (blue) and English (orange) Female Speakers.

As Figures 8 show, Korean female speakers tend to produce English reduced vowels as a lower and more back vowel, while the English female speakers tend to pronounce it as a mid central vowel, despite considerable overlap. More specifically, there is also a dot cluster indicating the /ə/ production by Korean female speakers (F1:700~850 Hz, F2:1100~1750 Hz) on the lower right side. Also, there is a dot cluster by native English female speakers on the upper left corner (F1:300~500 Hz, F2:1700~2100 Hz).

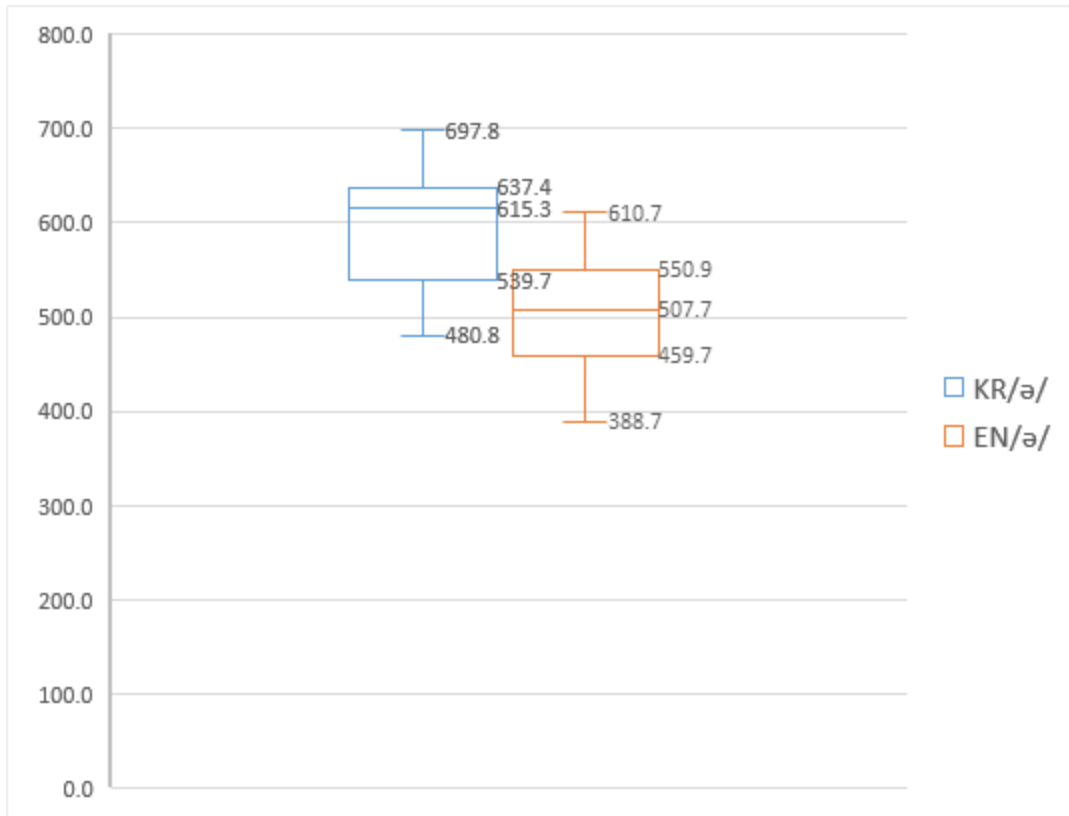


Figure 9. The Boxplot for /ə/ F1 Values Produced by Korean (blue) and English (orange) Female Speakers.

Referring to Figure 9, F1 boxplot for Koreans is much higher visually than the boxplot for English females, and that there seems to be very little overlap between them, which is consistent with the statistical significant difference presented earlier. At least 75% of English female speakers produced /ə/ with a formant value of 459.7 Hz or higher than that, and Korean female speakers produced /ə/ with a formant value of 539.7 Hz or higher than that. Unlike Korean male speakers, the boxplot by Korean female shows a slightly negative skew, meaning the data by Korean female speakers consists of lower values than median. Also, the interquartile difference for Korean female speakers is 6.5 bigger than for English female speakers.

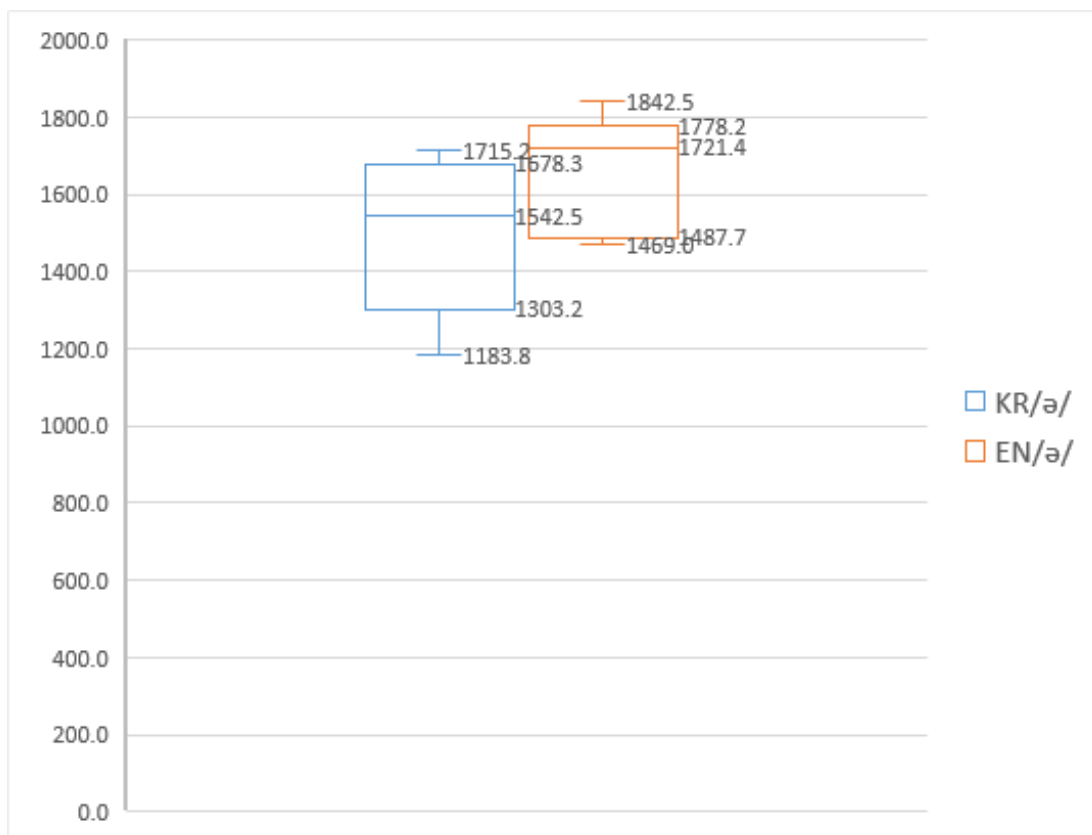


Figure 10. The Boxplot for /ə/ F2 Values Produced by Korean (blue) and English (orange) Female Speakers.

As Figure 10 shows, F2 boxplot for Koreans is slightly lower visually than the boxplot for English females, and that there seems to be some overlap between them, which is consistent with the small but statistically significant difference presented earlier. At least 75 % of English female speakers produced /ə/ with an F2 value of 1487.7 Hz or more than that, and Korean female speakers produced /ə/ with an F2 value of 1303.2 Hz or more than that. Both boxplots were negatively skewed, and the interquartile difference for Korean female speakers is 84.6 bigger than for English female speakers.

In conclusion, even though there are some differences in values such as mean, minimum and maximum values between English and Korean speakers, the interquartile range indicating middle 50% of values, the F1 values for /ə/ produced by Korean speakers were higher than

English speakers regardless of their gender. In addition, F2 values for /ə/ produced by Korean speakers were lower than English speakers regardless of their gender. This analysis demonstrates that there is a definite discrepancy in the quality of /ə/ production of an unstressed vowel between Korean and English speakers.

The results of the scatter plots seem to indicate that English reduced vowels produced by the Korean speakers might be assimilated into Korean's /ʌ/, which is a little bit lower and further back vowel than English /ə/ (See Table. 1) in the Korean vowel system, but it is similar enough in quality. If so, Korean speakers might not produce unstressed vowels but rather full vowels with a quality similar to that of the English reduced vowel, /ʌ/, which is in their native vowel inventory. Using a vowel quality in the native vowel inventory to approximate a vowel quality in the target language can be considered negative transfer (Flege, 1987). Thus, rather than reducing a vowel to conform to English stress patterns, Korean speakers of English focus on vowel quality to achieve a similar effect.

To make sure whether or not the /ə/ productions by Korean speakers are /ʌ/-like, the formant values for stressed and unstressed vowels in the word *color* are compared in Figure 11 and 12 since the stressed vowel in *color* should be a full /ʌ/ in English and the unstressed vowel is supposed to be reduced, and therefore, /ə/-like.

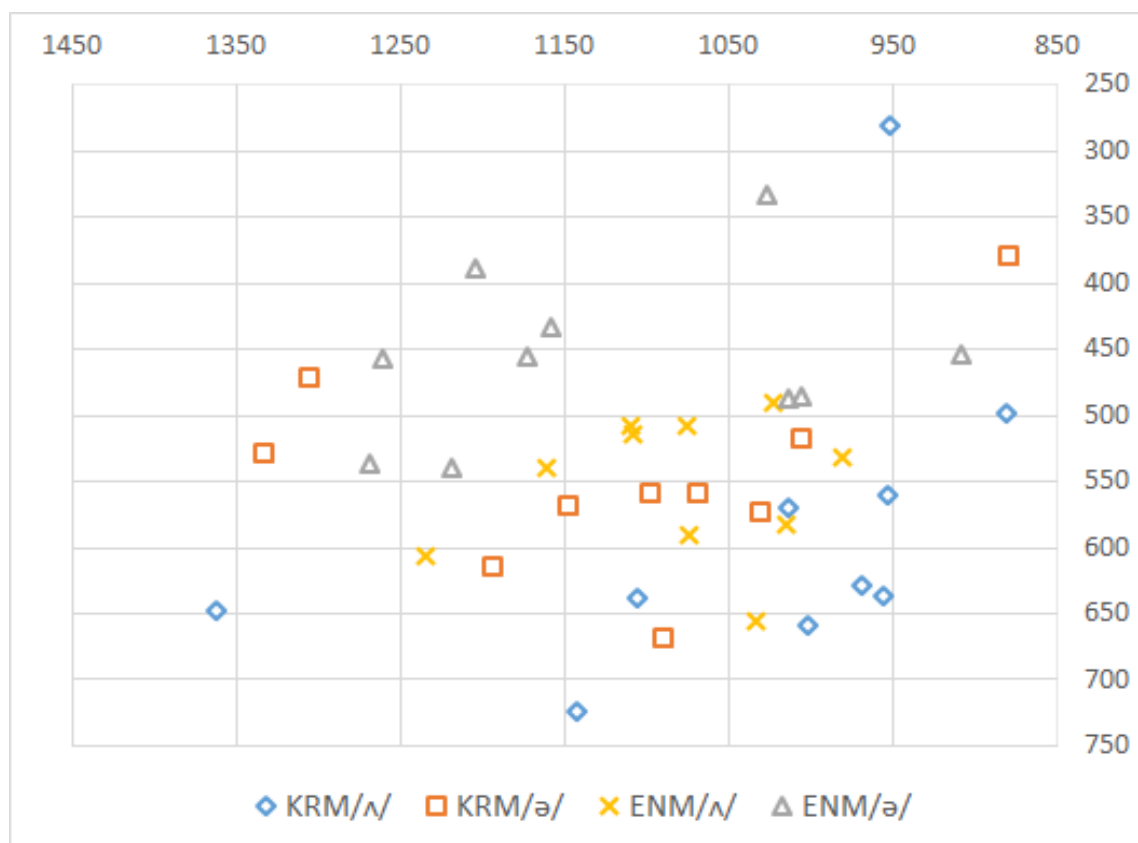


Figure 11. The Comparison of Stressed Vowel /ʌ/ and Reduced Vowel /ə/ Productions in the Word Color by Male Speakers (KRM = Korean male speakers, ENM = English male speakers).

As demonstrated in figure 11, the reduced vowels produced by Korean male speakers were definitely similar to the /ʌ/ produced by English male speakers. The dot cluster for /ʌ/ and /ə/ productions by Korean male speakers, the individual dots were overall concentrated in between F1:550~700 Hz and F2:950~1150 Hz although the /ʌ/ productions by Korean male speakers are slightly lower and further back than the /ə/ productions by the same L1 speakers.

The average F1 and F2 values for the stressed vowel /ʌ/ and unstressed vowel /ə/ produced by Korean and English male speakers were compared in Table 5. Formant values for all vowels appear to be very similar, suggesting similar vowel qualities.

Table 5.

The Averages of F1 and F2 for the Stressed Vowel /ʌ/ and Unstressed Vowel /ə/ Produced by Korean and English Male Speakers

	/ʌ/		/ə/	
	F1	F2	F1	F2
KRM	584.4 Hz	1033.3 Hz	543.8 Hz	1115.1 Hz
ENM	552.6 Hz	1081.4 Hz	456.9 Hz	1123.4 Hz

Notes. KRM = Korean male speakers, ENM = English male speakers

Furthermore, to ensure the statistical significance and compare how the /ʌ/ and /ə/ productions by Korean and English male speakers are different, p-values are calculated in the following table.

Table 6.

The P-values for F1 and F2 Produced by Korean and English Male Speakers

Color /'kʌlə/		p-value	
		F1	F2
KRM /ʌ/	KRM /ə/	0.391	0.201
KRM /ʌ/	ENM /ə/	0.00318	0.145
KRM /ə/	ENM /ə/	0.0214	0.866
KRM /ə/	ENM /ʌ/	0.743	0.46
KRM /ʌ/	ENM /ʌ/	0.438	0.32

As Table 6 shows, there was no significant effect between /ʌ/ and /ə/ produced by Korean male speakers on F1 and F2, meaning that Korean male speakers did not clearly distinguish the two vowels and did not reduce the unstressed vowel. Moreover, there was no statistically significant effects of language between the productions of /ə/ by Korean male speakers and /ʌ/

by English male speakers on F1 and F2. There was also no statistically significant effects of language between the productions of /ʌ/ by Korean male speakers and /ʌ/ by English male speakers on F1 and F2. This means that the productions of /ʌ/ and /ə/ by Korean male speakers were similar to the /ʌ/ produced by English male speakers.

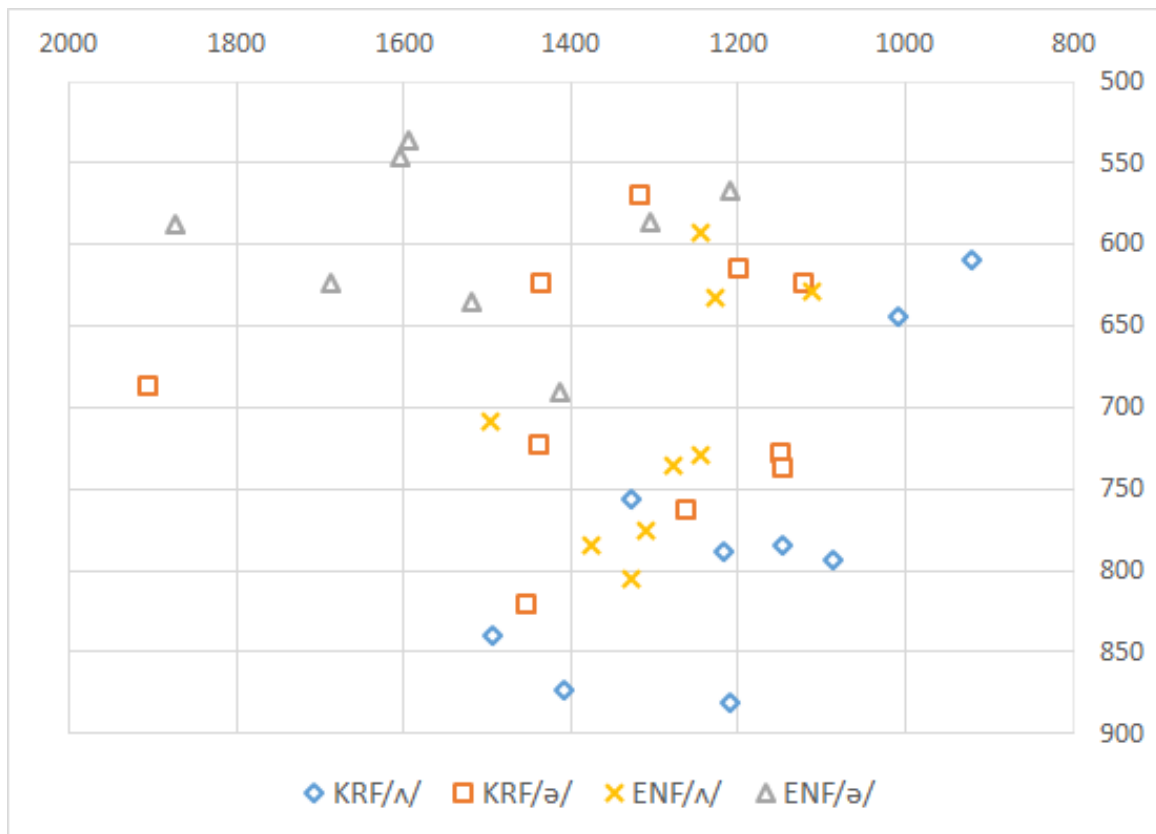


Figure 12. The Comparison of Stressed Vowel /ʌ/ and Reduced Vowel /ə/ Productions in the Word Color by Female Speakers (KRF = Korean female speakers, ENF = English female speakers).

Similar to the results for male speakers, the /ə/ produced by Korean female speakers were close to the /ʌ/ productions by English female speakers. For example, some /ʌ/ produced by both Korean and English female speakers are close to each other, and they were concentrated in between F1:700~850 Hz and F2:1100~1400 Hz even though the /ʌ/ grouping by Korean female speakers was slightly lower and further back than English speakers.

The average F1 and F2 values for the stressed vowel /ʌ/ and unstressed vowel /ə/ produced by Korean and English female speakers were compared in Table 7. The female vowels appear to be lower in quality than the male vowels, with an apparent difference between the Korean /ʌ/ and English /ə/.

Table 7.

The Averages of F1 and F2 for the Stressed Vowel /ʌ/ and Unstressed Vowel /ə/ Produced by Korean and English Female Speakers

	/ʌ/		/ə/	
	F1	F2	F1	F2
KRF	818.9 Hz	1337.7 Hz	688.7 Hz	1343.3 Hz
ENF	687.4 Hz	1261.8 Hz	571.6 Hz	1522 Hz

Notes. KRF = Korean female speakers, ENF = English female speakers

Furthermore, to determine the statistical significance and compare how the /ʌ/ and /ə/ productions by Korean and English female speakers are different, p-values are calculated in the following table.

Table 8.

The P-values for F1 and F2 Produced by Korean and English Female Speakers

Color /'kʌlə/		p-value	
		F1	F2
KRF /ʌ/	KRF /ə/	0.0254	0.973
KRF /ʌ/	ENF /ə/	0.000671	0.258
KRF /ə/	ENF /ə/	0.0024	0.0147
KRF /ə/	ENF /ʌ/	0.973	0.342
KRF /ʌ/	ENF /ʌ/	0.0565	0.624

As Table 8 shows, there was an effect between /ʌ/ and /ə/ produced by Korean female speakers on F1, but not on F2, meaning that Korean female speakers did not clearly distinguish the two vowels. Moreover, there was no statistically significant effects of language between the productions of /ə/ by Korean female speakers and /ʌ/ by English female speakers on F1 and F2. There was an effects of language between the productions of /ʌ/ by Korean female speakers and /ʌ/ by English female speakers on F1, but not on F2. This means that the productions of /ʌ/ and /ə/ by Korean female speakers were somewhat similar to the /ʌ/ produced by English female speakers. The results indicate that both /ʌ/ and /ə/ productions by Korean female speakers were /ʌ/-like by English female speakers.

In summary, the /ə/ by Korean speakers tend to be similar to the /ʌ/ by English speakers regardless of their gender. Moreover, the differences between /ə/ and /ʌ/ productions by Korean male speakers are not very significant, and Korean female speakers also tend to produce reduced vowels not very /ə/-like as English speakers do despite the visual differences.

Next, the unstressed vowel /ɪ/ in the words *pointed* and *dessert* by all speakers were compared to determine how the unstressed vowel productions are different between native English and Korean speakers. The reason for this analysis is that not all reduced vowels in English tend to be produced as /ə/; sometimes, reduced vowel quality is higher, more akin to /ɪ/, especially near alveolar consonants. Therefore, the following analysis examines if the Korean speakers produced all their reduced vowels as a /ʌ/, showing an across-the-board negative transfer of /ʌ/ to English, or if there could be alternatives sensitive to vowel quality differences.

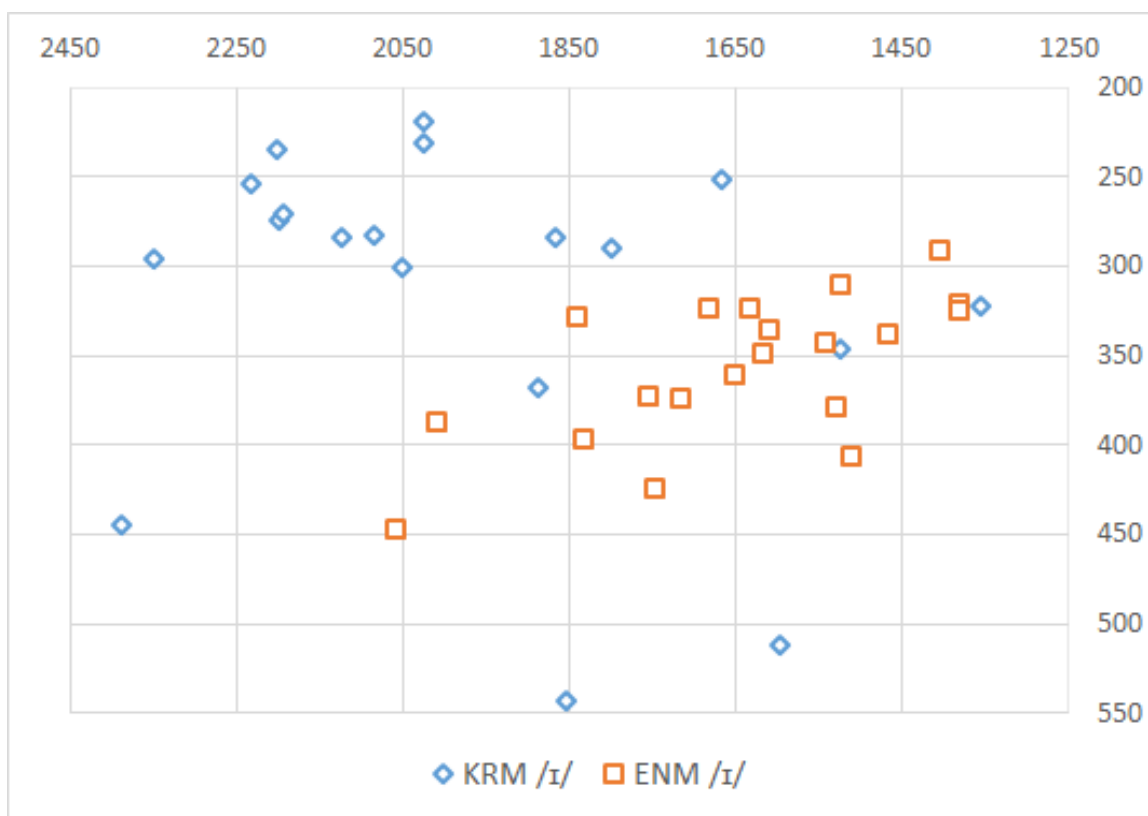
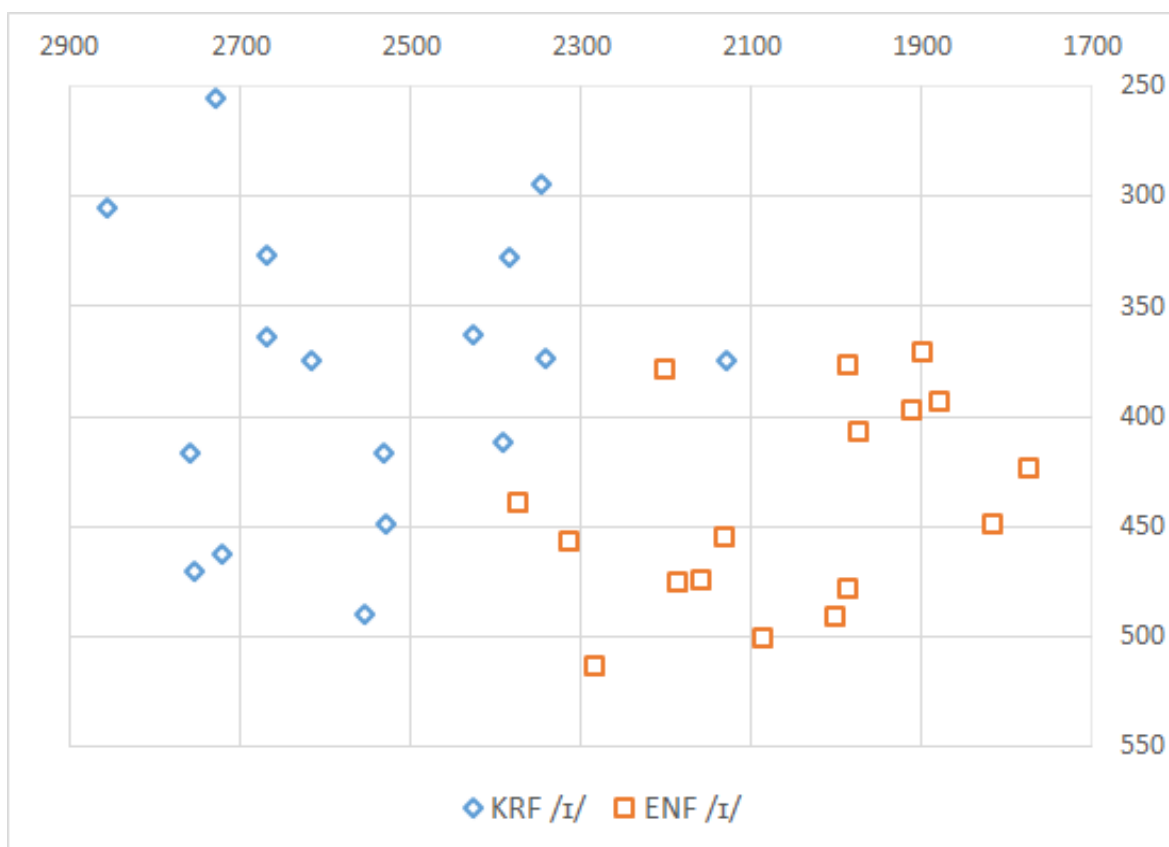


Figure 13. The Comparison of Unstressed Vowel /ɪ/ Productions in the Words Pointed and Dessert by Male Speakers.

The average F1 and F2 values for the unstressed vowel /ɪ/ productions in the two words regardless of speakers' L1s and gender were 394.1 Hz and 2044.6 Hz respectively. The average F1 and F2 values for /ɪ/ by Korean male speakers were 346.9 Hz and 1971.5 Hz, while the averages by English male speakers were 356.5 Hz and 1644.5 Hz. The average F1 and F2 values for /ɪ/ by Korean female speakers were 419.3 Hz and 2532.4 Hz, while the averages by English female speakers were 453.6 Hz and 2029.9 Hz. As Figures 13 and 14 show, Korean speakers tended to produce higher and more fronted vowels for the unstressed vowel /ɪ/ than English speakers regardless of their gender. On the other hand, the unstressed vowels produced by English speakers were lower and further back vowels.



Korean and English male speakers not really on F1 ($t(40) = -0.255, p = 0.802$)¹⁵, but great effects on F2 ($t(40) = 4.342, p = 0.000101$)¹⁶. There was also some effects of language between the productions of /ɪ/ by Korean and English female speakers not really on F1 ($t(40) = -1.614, p = 0.129$)¹⁷, but significant effects on F2 ($t(40) = 6.052, p < 0.05$)¹⁸.

In view of the results so far, it is likely that the vowel qualities of reduced vowels by Korean speakers vary depending on L1 vowel inventory. As we discussed concerning the formant analysis of /ə/, Korean tends to assimilate the English reduced vowel into the approximate vowel in the Korean phonological system when there is no same vowel in the Korean phonological system; then they produce it as a full vowel. It appears to be a case of negative transfer. Conversely, if there is the same quality of vowel in the L1 vowel inventory, it is expected that a positive transfer also could occur (Flege, 1987). Thus, it is worthwhile comparing the vowel quality of /ɑ/, which is in both Korean and English, in the compound words *wristwatch* and *racecar* because there might be a positive transfer. Additionally, as demonstrated in the compound words analysis before, the vowel reduction patterns for English compound words seem to have great variations in view of the results so far analyzed, so it is expected that the unstressed vowel /ɑ/ in two English words might not clearly be /ə/ in case of compound words.

¹⁵ The function in R is: `lmer(F1~L1+(1|speaker), krmenmi)`

¹⁶ The function in R is: `lmer(F2~L1+(1|speaker), krmenmi)`

¹⁷ The function in R is: `lmer(F1~L1+(1|speaker), krfeffi)`

¹⁸ The function in R is: `lmer(F2~L1+(1|speaker), krfeffi)`

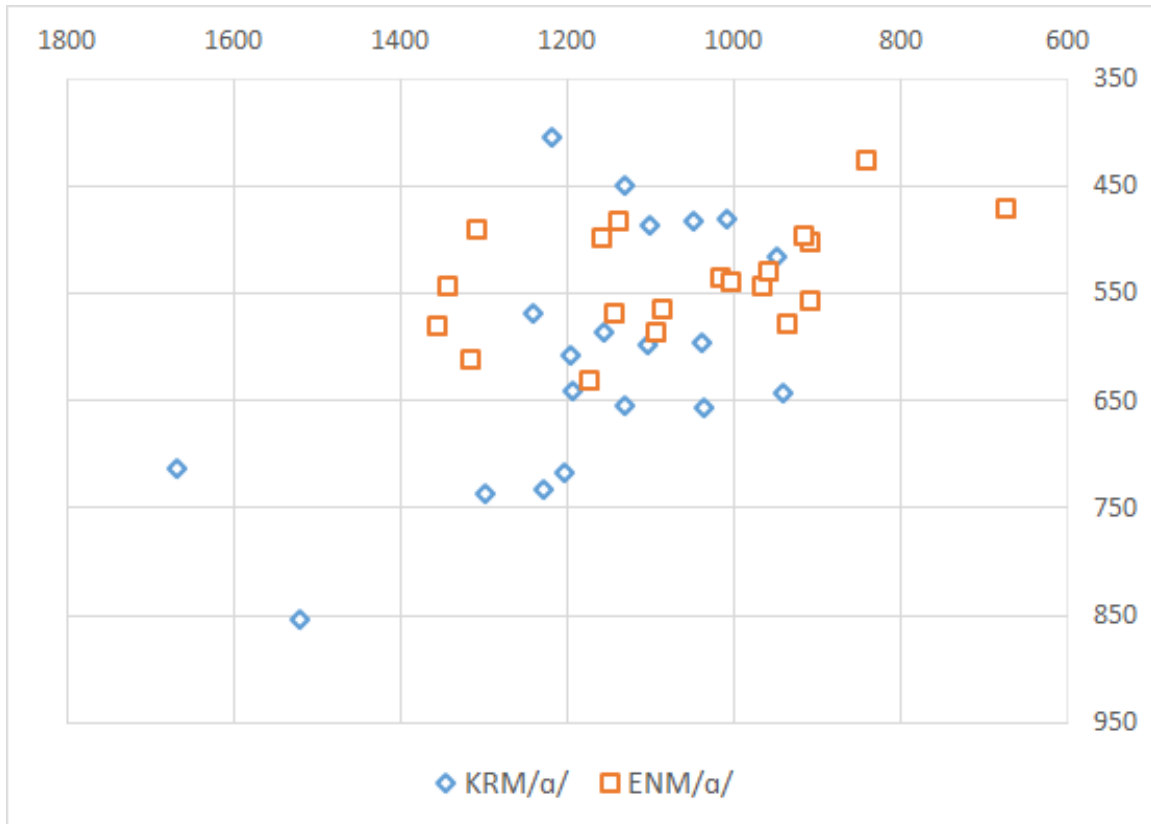


Figure 15. The Comparison of Unstressed Vowel /a/ Productions in the Words Wristwatch and Racecar by Male Speakers.

The unstressed vowel /a/ shared in the words *wristwatch* and *racecar* were compared in Figure 15 and 16. The average F1 and F2 values for the unstressed vowel /a/ productions in the two words regardless of speakers' L1s and gender were 642.4 Hz and 1232.9 Hz respectively. The average F1 and F2 values for /ɪ/ by Korean male speakers were 605.8 Hz and 1170.1 Hz, and the averages by English male speakers was 536.3 Hz and 1061.8 Hz. The average F1 and F2 values for /ɪ/ by Korean female speakers were 704.9 Hz and 1367.9 Hz, and the averages by English female speakers were 722.8 Hz and 1331.7 Hz.

Interestingly, there was a lot of overlap between the productions by English and Korean speakers even though there were also a few variations among them. For instance, the productions by male speakers for the unstressed vowel /a/ overall converged between F1:450~750 Hz and

F2:900~1400 Hz. Statistically, there were small effects of language between the productions of /a/ by Korean and English male speakers on F1 ($t(40) = 2.538$, $p = 0.02$)¹⁹ and F2 ($t(40) = 1.904$, $p = 0.0646$)²⁰.

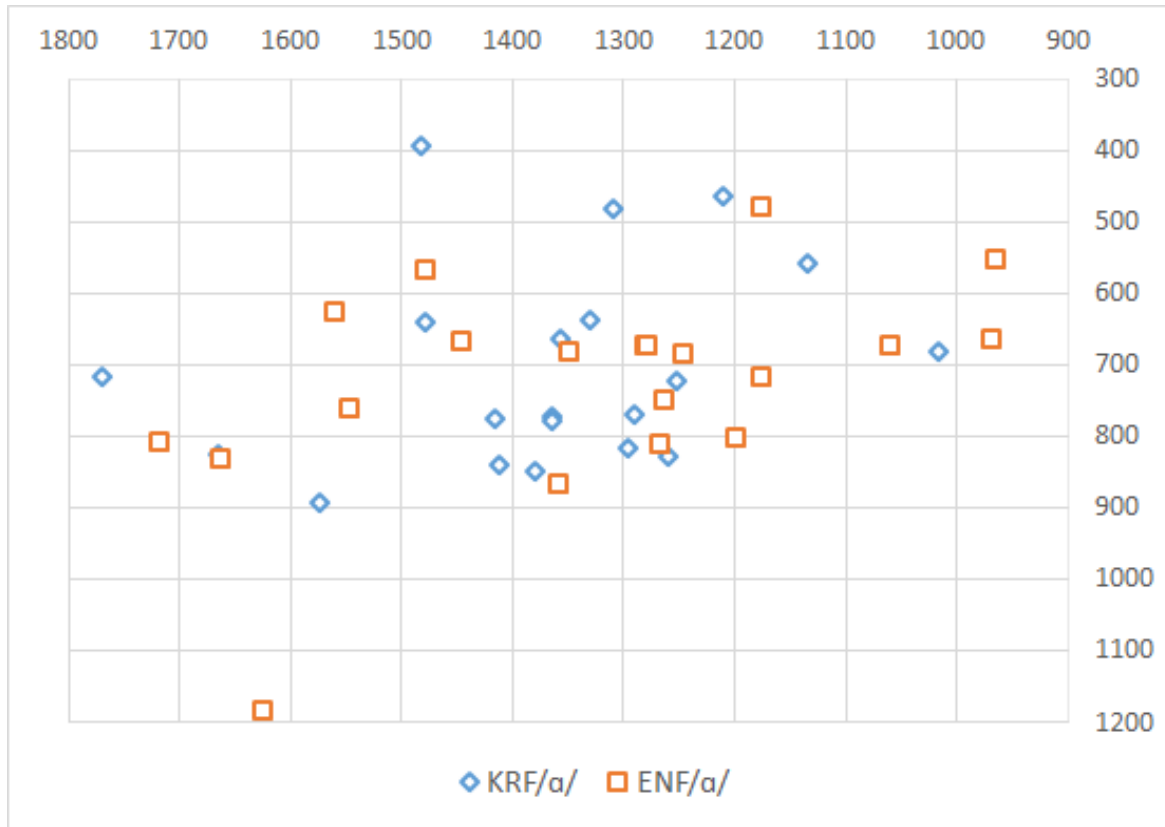


Figure 16. The Comparison of Unstressed Vowel /a/ Productions in the Words Wristwatch and Racecar by Female Speakers.

The productions of /a/ by female speakers were also very similar to each other, and both were widely dispersed. It means that the qualities of the vowel /a/ were almost the same as each other. The reason why both productions for the unstressed vowel were similar enough is thought to be that the vowel /a/ exists in both the English and Korean vowel systems, and there might be positive transfer. Statistically, there was no great effects of language between the productions of

¹⁹ The function in R is: `lmer(F1~L1+(1|speaker), krmenma)`

²⁰ The function in R is: `lmer(F2~L1+(1|speaker), krmenma)`

/ɑ/ by Korean and English female speakers on F1 ($t(40) = -0.396, t = 0.694$)²¹ and F2 ($t(40) = 0.611, t = 0.548$)²².

Based on the results for formant analysis, it can be concluded that the productions of unstressed vowels are influenced by the L1 phonological systems regardless of the types of word formation. For both non-compound and compound words, if there is a same or similar vowel in the L1 vowel inventory, Korean speakers are able to produce a similar quality of vowel as English speakers do. However, if there is no same or similar vowel in the L1 vowel inventory, there is a vowel approximation by Korean speakers to a central vowel, and it appears to more /ʌ/-like than English /ə/.

²¹ The function in R is: `lmer(F1~L1+(1|speaker), krfa)`

²² The function in R is: `lmer(F2~L1+(1|speaker), krfa)`

DISCUSSION

In most cases, the duration ratios of unstressed vowels by Korean speakers were over 1, meaning Korean speakers did not reduce unstressed vowels and pronounced them longer than stressed vowels. On the other hand, the duration ratios by English speakers were nearly 1 or under, meaning English speakers reduce unstressed vowels. In the case of compound words, there were many variations. For example, native English speakers reduced the unstressed vowel in *racecar*, but did not reduce the unstressed vowels in *wristwatch* and *football* and produced the unstressed vowel much longer than the stressed vowel. This variation supports the findings that English stress patterns of compound words have considerable variation from previous studies (Kunter, 2011; Plag, 2006; Sabine Arndt-Lappe, 2011; Yavaş, 2011). Although there were several concerns about the variation of the data, the validity and reliability of the results are supported by a t-test. Also, the results are enough to support our hypotheses of the current study. There were significant effects on duration analysis data, and it indicates that Korean speakers, regardless of their gender, tend not to reduce unstressed vowels as much as English speakers.

With respect to the formant values for the production of English unstressed vowels, especially the pronunciation of /ə/, the results of the current study showed that Korean speakers tended to pronounce /ə/ with higher F1 and lower F2 than English speakers. That is, Korean speakers tended to produce the /ə/ as lower and further back vowels than English speakers, meaning Korean speakers might assimilate the English /ə/, which does not exist in their vowel system, into [ʌ], which exists in their vowel inventory. This finding actually corresponds with the results cited by Han et al. (2011). Another unstressed vowel /ɪ/ also is produced differently between Korean and English speakers. For instance, the unstressed vowel /ɪ/ pronounced by

Korean speakers was much higher and fronted than English, whereas the productions of /ɪ/ by English speakers were marked as mid central vowels, which are more /ə/-like. It can be concluded that Korean speakers might not reduce the unstressed vowel and assimilate it into the full high front vowels /i/ or /i/, which are in their vowel inventory, and it agrees with the finding by Lee et al. (2006).

These results support the PAM theory, meaning Korean learners of English tend to produce similar sounds to their L1 perceptual system when they pronounce English words and sentences. Consequently, they have a foreign accent, which identifies them as Korean speakers. On the other hand, if there are overlaps between the L1 and L2 phonology systems, it appears to be easier for L2 learners to produce L2 pronunciations, and the productions might be less accented. In the case of the quality of the unstressed vowel /ə/, the productions by Korean and English speakers were very similar to each other, meaning that Korean speakers are able to pronounce /ə/ with the same vowel quality as English speakers do because Korean speakers have the same vowel in their vowel system. However, even though the quality of the unstressed vowel in the compound word is the same, Korean speakers do not reduce unstressed vowels depending on the weight of vowels because of negative transfer of their suprasegmental characteristics being syllable-timed.

In addition, there were several interesting findings. In the process of measuring the duration of stressed and unstressed vowels, it was a difficult to determine clear boundaries between a vowel and consonant, especially if the vowel is pronounced with the sonorants such as /l/, /r/, /m/, and /n/ in coda position. The reason is the phonological variations, which are called syllabic consonants. Syllabic consonants are nasal and liquid consonants, and they become the nucleus of a syllable in post-unstressed syllables, so the consonants merge with the following

vowels (Anderson, 2018). For instance, *people*, *color*, *football*, *racecar*, *quarter*, and *pigeon* in our target words contain syllabic consonants, so the vowels in the second syllables, which are in an unstressed syllable, are merged with following sonorants. Thus, there is a concern that the length of the duration for unstressed vowels in several words containing syllabic consonants might be measured quite longer since they merged with consonants.

Moreover, a couple of Korean male speakers pronounced the word *pointed* as *point*, so there is a concern that there is a variability in the result. Also, a few native English male speakers read sentences without intonation or too quickly, so it sounded like they did not put any stress on any of the words. On the other hand, some English female speakers exaggerated the enunciation of the past particle *-ed*, so the duration ratio value is slightly greater than that of the Korean female speakers. These are considered as limitations of using lab speech data which is monotonous and overly clear. Since the analysis was conducted based on existing data, there was a limitation in selecting the eleven words, especially the words which consisted of two syllables and included two vowels needing to be chosen from the given scripted speech. Also, the words were embedded in a sentence, so there were more variations that influenced the duration of each vowel because of the phrasal pitch accent.

In terms of the vowel qualities, there were several mispronounced words in the productions from non-native speakers even though it was expected that the speakers might pronounce every single word clearly since it was a lab speech based scripted speech collection. For instance, most of the Korean male participants pronounced the word *dessert* [dɪ'zɜ:t] as *desert* ['dezərt], and two out of the ten Korean female participants made the same mistake. Fortunately, when Korean speakers spoke the following sentence *he had apple pie*, some of them noticed their mistakes immediately and fixed the mispronunciation by repeating the words by

themselves, but some of them did not even seem to notice their mistakes and did not correct them at all. Therefore, as acoustic-phonetic research, it is concerning that the vowel duration and formant analysis for the word *dessert* is difficult to analyze and get the correct results in this study since the stress position and also the vowel qualities are obviously different for the word *dessert* and *desert*. For example, the stress for the word *dessert* is put on the second syllable and the unstressed vowel in the first syllable is /ɪ/, but the stress for the word *desert* is put on the first syllables and the stressed vowel in the first syllable is /e/.

Pedagogical Implications

Based on the results, it might be useful for Korean learners of English to learn suprasegmentals such as English vowel reduction and linking occurring in connected speech in American English to improve their intelligibility. In a study by Anderson-Hsieh (1990), the Chinese and Korean international teaching assistants (ITAs) who did not pass the oral proficiency test had severe issues with suprasegmentals, so the researcher provided pronunciation instruction focusing on suprasegmentals for them. The objective of the class was to help students' understanding of English stress, rhythm, intonation, linking and reduction, and to increase awareness of the suprasegmental differences through the comparison in production between the target students and native speakers' language. In addition, the languages used in the class materials were related to chemistry which was the students' major field to improve their comprehensibility when they spoke about their academic disciplines using English. The class materials contained detailed explanations of different types of intonations such as rising and falling by representing the intonation contours on the various sentences directly. Also, identification exercises on word stress, intonation, linking, reduction, and rhythm were provided for students to practice. Consequently, there was improvement in speaking test scores by the

ITAs compared between the test administered at the beginning of the semester and the test at the end of the semester. Also, students showed positive reactions to the learning materials.

To achieve improvement effectively, as Lee et al. (2006) suggested, it would be beneficial for early learners to develop more native-like pronunciation since young learners might not be influenced by the strong negative effects of their L1 and be able to use a variety of acoustic cues in the L2 instead of assimilating the L2 to the L1. However, pronunciation instruction is often offered as a part of language classes rather than a stand alone course in most cases (Derwing & Munro, 2015). For instance, previous research found that many instructors spend less than one hour a week for pronunciation instruction and devote a smaller portion of class to pronunciation than to vocabulary and grammar (Foot et al., 2011; 2016). Thus, many students do not have enough opportunity to learn different phonetic systems in the second language and also to be exposed to various phonological variation rules such as allophones and linking occurring in L2 segmentals and suprasegmentals. As a result, they use acoustic cues in their L1 to perceive and produce L2 pronunciation.

Since there is a big potential for course and material development in pronunciation instruction, it would be useful for instructors to know what kinds of pronunciation training and tools exist and how to use them. A lot of researchers recommend that computer assisted pronunciation training (CAPT) facilitates learners to learn and teachers to evaluate the production and perception of pronunciation in the L2 because CAPT is repeatable, accurate, reliable, quick, and also provides visuals (Pennington, 1999; Pi-Hua, 2006; Scarcella & Oxford, 1994). It allows teachers to identify various pronunciation issues of learners with less time-consuming activities and to give explicit feedback to their learners. In particular, the speech analysis device, Praat, which was used in this study can show intonation contours, pitches,

intensities, and durations of the speech sounds by speakers (Le & Brook, 2011). That is, there are great benefits for students to utilize the device and to have more chances to practice their pronunciation in the L2 based on rich information regarding both segmentals and suprasegmentals although it might take some time for users to become familiar with handling the devices.

CONCLUSION

The importance of learning the suprasegmental aspect of pronunciation as it is related to developing fluency and intelligibility in English is unquestionable in the literature. This is especially true when the learner's native language phonology differs substantially from English. There are several differences between Korean and English phonological systems, for example, vowel inventory, stress and intonation patterns, which might affect Korean learners of English fluency and intelligibility, contributing to the occurrence of foreign accents of English by Korean speakers. In particular, English is a stress-timed language, so unstressed syllables tend to be pronounced shorter and with a reduced vowel quality than stressed syllables. On the other hand, Korean is a syllable-timed language, so every syllable is approximately pronounced with equal duration and nearly negligible vowel quality reduction. In the present study, the production of unstressed English vowels, especially duration and formant values produced by Korean speakers were examined. To determine whether or not there are some discrepancies, which might reflect negative transfer effects from L1, corpus data of Korean speakers of English was analyzed.

In terms of methodology, Wildcat Corpus was used, and the recording files by 40 speakers, equally divided across native language (English and Korean) and gender (male and female), were extracted for duration and formant analysis. In the duration analysis, the duration ratios of stressed to unstressed vowels in the same word by both English and Korean speakers were compared. The results demonstrated that Korean speakers tend to produce the unstressed vowels with equal or longer duration than stressed vowels. Formant frequencies F1 and F2, which determine the quality of vowels, by English and Korean speakers were also compared. The results showed that Korean speakers tend to produce English /ə/ as more like /ʌ/, which is

slightly lower and further back than /ə/, and English /ɪ/ as higher and fronted vowels, but the productions of /ɑ/, which exists in both the Korean and English vowel inventories, were overlapped.

The findings of the duration and formant analysis provide us some clues as to what affects Korean learners of English accent. First, the duration ratios for the unstressed vowels by Korean speakers were greater than that of English speakers, regardless of gender. Next, while the qualities of the unstressed vowels by native English speakers were consistently produced as a mid-central vowel, the qualities by Korean speakers varied depending on the types of unstressed vowels. Although the discrepancies were still not substantial, it is clear that there is a certain extent of variation of the unstressed vowels by Korean speakers. Korean speakers tend to assimilate some English unstressed vowels into acoustically similar vowels in the Korean vowel inventory if they do not have the same vowel. Then they produce them as full vowels. Consequently, vowel reduction did not occur. This assimilation is considered as creating negative and positive transfers when Korean speakers produce unstressed vowels.

For future research, it would be useful to have more data and compare a range of unstressed vowels in more words across different phonological segmental contexts because there are a lot of variations on the vowel productions even in English. For instance, reduced vowels are easy to merge with consonants, especially sonorants in coda position, and to pronounce unclearly (Ladefoged & Johnson, 2014). It makes the measurement of identifying the boundaries between the unstressed vowels and following consonants difficult. Having the vowels in more varied segmental contexts, such as between stops, would mitigate the problem.

In addition, the influence of orthographic differences is one consideration. For example, vowel reductions between two consonants in the regular past tense verbs such as in the word

pointed might not occur because second language learners might produce the vowel as it is written. As discussed in the discussion section, native English speakers also do not reduce it when they try to enunciate the unstressed vowel /ə/ in the second syllable. Furthermore, stressed patterns for compound words are affected by not only morphological components but also by their lexical-semantic nature, as they are composed of two roots rather than a single root (Lieber, 2010). Having two roots could impact measurements, making it difficult to determine which vowel would be an unstressed vowel in a word without contextual understanding.

Beyond that, it would be ideal to have not only lab speech data but also spontaneous speech data. As a previous study demonstrated, word stress in natural discourse includes rich emotions and is more communicative than lab speech (Xu, 2010). Thus, it would be meaningful and worthwhile to look at the productions of unstressed vowels produced in natural conversation because it reflects actual language use which has more practical and valid pedagogical applications and the ultimate goal of learning to communicate in context. For these reasons, having more data could help identify vowel reduction patterns more accurately and give better support to finding negative and positive transfers in productions of unstressed vowels by Korean speakers and maximize the reliability and validity of the results.

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APPENDIX A

Scripted Corpus

1. He pointed at the cents.
2. Dad talked about the bomb.
3. Mom pointed at his father.
4. Many people like to start the day with a cup of coffee.
5. We pointed at the bird.
6. Last night, they had beef for dinner.
7. She made the bed with clean sheets.
8. We read about the family.
9. She pointed at her head.
10. At breakfast he drank some orange juice.
11. Dad read about the sky.
12. A wristwatch is used to tell the time.
13. Bob wore a watch on his wrist.
14. We talked about the water.
15. She looked at the clock.
16. He pointed at the animals.
17. The color of a lemon is yellow.
18. Dad pointed at the grass.
19. Rain falls from clouds in the sky.
20. The good boy is helping his mother and father.

21. Dad talked about the sheets.
22. Mom thinks that it is yellow.
23. Football is a dangerous sport.
24. The team was trained by their coach.
25. In spring, the plants are full of green leaves.
26. Elephants are big animals.
27. He looked at her wrist.
28. We read about the coach.
29. When sheep graze in a field, they eat grass.
30. A racecar can go very fast.
31. This is her favorite week.
32. A quarter is worth twenty-five cents.
33. He washed his hands with soap and water.
34. The war plane dropped a bomb.
35. Mom looked at the juice.
36. February has twenty-eight days.
37. She talked about their necks.
38. For dessert, he had apple pie.
39. She talked about the leaves.
40. We looked at the story.
41. This is her favorite sport.
42. People wear scarves around their necks.
43. We heard the ticking of the clock.

44. Mom looked at her feet.
45. The sport shirt has short sleeves.
46. He read about the trees.
47. People wear shoes on their feet.
48. Mom talked about the pie.
49. I wear my hat on my head.
50. He looked at the sleeves.
51. This is her favorite time.
52. There are many days.
53. Birds build their nests in trees.
54. A pigeon is a kind of bird.
55. He talked about the dinner.
56. Mom pointed at the coffee.
57. My parents, sister and I are a family.
58. She thinks that it is fast.
59. Monday is the first day of the week.
60. A book tells a story