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Gender and age differences in sub-phonemic variants of /o/ in Korean spontaneous speech: A corpus-based study*

Eunkyung Yoon
(Daegu Cyber University)

Yoon, Eunkyung. 2020. Gender and age differences in sub-phonemic variants of /o/ in Korean spontaneous speech: A corpus-based study. *Linguistic Research* 37(3): 617-637. The purpose of this corpus-based study is to identify sub-phonemic variants of /o/ in standard Korean, focusing on phonetic variants [o] and [u] of the phoneme /o/. The major concerns of this paper are (1) substitution rates in word-final position, whereby the mid-back vowel [o] is substituted by the high-back vowel [u], and (2) the acoustic analysis of F1 and F2 (Hz) values for [o] and [u] according to gender and age differences. A total of 40 participants' speech samples (five females and five males in each of four age groups: teens, 20s, 30s, and 40s) were selected from the Korean Corpus of Spontaneous Speech. As a result, the study confirmed the following: Although the [u] substitution rates of older female speakers were significantly higher than those of male younger speakers, younger female speakers reported a relatively shorter Euclidean distance than older male speakers. Once younger speakers substitute [u] for [o], the Euclidean distances between [o] and [u] are much closer than in older speakers; this finding is consistent with previous studies' findings. What is noteworthy about this acoustic analysis is that statistically significant differences were found in F2 values in both male and female groups, but not in F1 values. This study also suggests that the phonetic spaces of [o] and [u] is getting closer in terms of F2 values (within 1 standard deviation) with a decrease in the ages of both men and women, which can be robust evidence that /o/-shift is still ongoing in a different direction, and might lead to another chain shift triggered by [o] moving inwards that results in high-back vowel [u] pushing in modern Korean. (**Daegu Cyber University**)

Keywords Korean monophthong, /o/-raising, vowel shift, [u] substitution, sub-phonemic variants

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1. Introduction

Many studies (Chae 1999; Kang 2005; Han and Kang 2013; Kang and Han 2013; Kang 2014; Yoon and Kim 2015; Kang and Kong 2016; Lee et al. 2016; Ha and Oh 2017; Lee et al. 2017; Byun 2018; Yang 2018; Yoon 2020) reveal that /o/-raising has been progressing in standard Korean. The shift of the mid-back rounded vowel /o/ being raised to the high-back rounded [u] in Korean is referred to as /o/-raising. A recent corpus-based study by Yoon (2020) found that [o] was substituted by [u] at a high rate of approximately 50% in connective endings, adverbs, and particles except for the nominal items, which showed a substitution rate less than 5%. According to Paek (1988), /o/ and /u/ vowels were historically used interchangeably during the sixteenth and seventeenth centuries. In the eighteenth century, the change from /o/ to /u/ took place in one direction. At the beginning of this language change, /o/-raising was prominently found in word-final position but spread gradually across words (Kang 2014).

The majority of previous studies used either read-speech or spontaneous speech from a massive corpus or interview recordings to verify /o/-raising in speech production. However, a few methodological issues need to be considered in analyzing the data. First of all, some researchers used the scripts for read-speech to obtain substitution rates or acoustic analysis (e.g., Hong 2013; Han and Kang 2013; Lee et al. 2017)—of course, this is a reasonable way to obtain proper speech samples. However, rather than read speech, spontaneous speech is required to precisely observe sub-phonemic variations. It is difficult to exclude the possibility that, unlike spontaneous speech, read-speech production might be realized as spelling pronunciation /o/ since it could be prompted by the letter “o” in the wordlist. Secondly, some papers (e.g., Kwon 2009) suggest substitution rates of [u] through the Hangul transcription of the Sejong corpus with no sound files, which makes it hard to access phonetic representations. Lastly, a corpus-based study of spontaneous speech was conducted by Yoon and Kim (2015), who measured the phonetic values of seven Korean vowels. They did not specifically consider the phonetic variants of a phoneme.

The purpose of the current study is to investigate gender and age differences in Korean sub-phonemic variants of /o/ based on the Korean Corpus of

Spontaneous Speech (hereafter, Seoul Corpus by Yun et al. 2015). Through two research methodologies, substitution rates from transcription files and acoustical analysis from sound files were selected for the present study. The acoustic properties of [o] and [u], such as the formant values (F1 and F2 in Hz) and Euclidean distances, were measured across gender and four different age groups ranging from 15 to 47 years of age. In particular, the present study was interested in the vowel quality of the [u] in the derived form of the phoneme /o/. By examining the current cross-generational phonetic differences between standard and actual pronunciations, this study also sought to predict future language changes.

2. Research method

2.1 Participants

The Seoul Corpus (2015) is a large-scale speech corpus that is composed of approximately 220,000 phrasal words containing audio and transcription files from a total of 40 subjects. Five women and five men each from four different age groups, teenagers and adults in their 20s, 30s, and 40s, participated in the study. The average age of male speakers in their teens was 15.6 (15~16) yrs., that of those in their twenties was 23.8 (22~26) yrs., that of those in their thirties was 34.4 (31~37) yrs., and that of those in their forties was 44 (43~47) yrs. The average age of female speakers in their teens was 16.8 (16~18) yrs., that of those in their twenties was 24.2 (22~27) yrs., that of those in their thirties was 34.6 (32~38) yrs., and that of those in their forties was 44.2 (43~46) yrs. For each speaker, 60 minutes of conversation was recorded. The recordings had the following form: One male or female researcher interviewed a subject regarding the latter's everyday life. The contents mainly comprised stories related to the participants' family, school, college major, workplace, society, and politics. The questions asked by the researchers were weakly recorded in audio files, which caused difficulties in understanding the contents and enabled the hearing of only the subjects' answers. On average, the subjects in their teenage years used 8,841 phrasal words (male : female = 4,571 : 4,270); those in their 20s used 10,749

phrasal words (male : female = 6,021 : 4,728); the subjects in their 30s used 12,675 phrasal words (male : female = 7,246 : 5,429); and those in their 40s used 12,292 phrasal words (male : female = 6,277 : 6,015). The recordings were made using a TASCAM HD-P2 recorder and an AKG C420 microphone using a sampling rate of 44.1 kHz with 16-bit quantization for each sample.

2.2 Data analysis

2.2.1 Extracting phonetic variants

The speech corpus analysis program Phonometrica (Eychenne and Courdès-Murphy 2019) was used to analyze Seoul Corpus (2015). We used all the data from the 240 audio (waveform) and text (Textgrid) files compiled in Seoul Corpus. In the Textgrid file provided by Seoul Corpus, the underlying form and the surface form are transcribed in a total of seven tiers in specific units of syllable, phrasal word, and utterance. In addition, the transcription conveniently extracted the required speech tokens since it is written according to its own conventions (e.g.,'oo' for /o/) of Seoul Corpus and is combined with Hangul transcription. Tier 1 is the "phoneme," which is divided into phonetic units of the phonetic surface form and Romanized. Tier 2 is "pWord.prono," and the surface form is segmented into units of word segments and then transcribed into Korean. Tier 3 is "utt.prono," and the phonetic surface form is transcribed in romanization into units of word segments. Tier 4 is "utt.prono," and the surface form is transcribed in Hangul (Korean) into units of utterance. Tier 5 is "pWord.ortho," whose underlying form is transcribed in Korean spelling by units of word segments. Tier 6 is "pWord.ortho" and transcribed in the underlying form in romanization by units of word segments and, finally, Tier 7 is "utt.ortho," whose underlying form is separated into utterance units and recorded in Korean. In this study, two steps were needed to extract the phonetic variants. The intervals ending with 'oo' from Tier 1 were first extracted using Phonometrica. This was followed by the extraction of all data having the surface form [o] 'oo' or [u] 'uu' for /o/ in Tier 3 using Python. As can be seen in Figure 1, to confirm the Korean transcription type of the two tiers, the data from

Tiers 2 and 3 were extracted and compared as well.

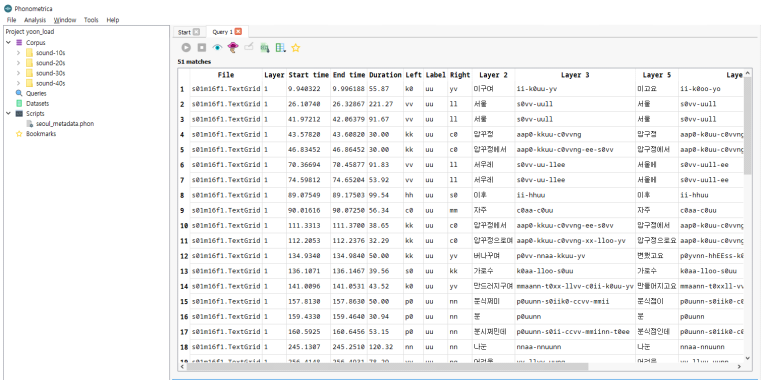

Figure 1. A screenshot of results from Phonometrica

In this study, 24,328 samples were extracted. Some tokens that were difficult to recognize even after the direct examination of audio files were excluded from data analysis since the subjects were repeating the same words, murmuring or speaking unclearly. In addition, 1,626 tokens were detected using vowels, other than the form of [o] or [u]. Finally, 22,702 tokens were collected for the analysis, which included 12,310 and 10,392 tokens for [o] and [u], respectively.

2.2.2 Acoustic analysis

To measure the vowel's formant value, the F1 and F2 values were automatically measured at 1/2 point of the steady-state in the spectrogram using the Praat script. The data for male speakers were set to 5,000 Hz and those for female speakers were set to 5,500 Hz. The formant (burg) method, which is a basic algorithm provided by Praat, was used.

Unlike the calculation of the substitution rate of [u] from Textgrids, speech analysis involved the presence of many outliers, since audio samples were extracted from a spontaneous speech corpus. Some tokens were excluded since they could not ensure accurate acoustic analysis. To minimize the outliers in the distribution, among the data corresponding to the quartile of the total number of tokens, only the speech tokens from the first lower quartile (Q1) to the third

upper quartile (Q3), which formed half a given data set, were analyzed.

In addition, the Euclidean distance of [o] and [u] was measured using the following formula: [o] = ($p1$, $p2$) and [u] = ($q1$, $q2$) in two dimensional space is (($p1$ - $q1$)^2 + ($p2$ – $q2$)^2)^(1/2) where p and q are formant values.

3. Results

3.1 Frequency of occurrence

Table 1 depicts the frequency of occurrence and rates of [o] and [u], which are phonetic forms of /o/ according to gender. As identified in section 2, the overall magnitude of utterances produced by male speakers was greater than that of female speakers. The occurrences of [o] were 12,348 (54.4%) for men and 10,354 (45.6%) for women. However, the substitution rate in which [o] is replaced with [u] was beyond half at 5,617 (54.2%) tokens in women, which is a higher rate compared to the rate of men with 4,775 (38.7%) tokens.

Table 1. Frequencies of occurrence and rates of [o] and [u] by gender

Number of Tokens	phonetic form	Frequency	Rate (%)
Female	[o]	4,737	45.8
(n=10,354)	[u]	5,617	54.2
Male	[o]	7,573	61.3
(n=12,348)	[u]	4,775	38.7

Figure 2 represents the distribution table of the substitution rates as a diagram.

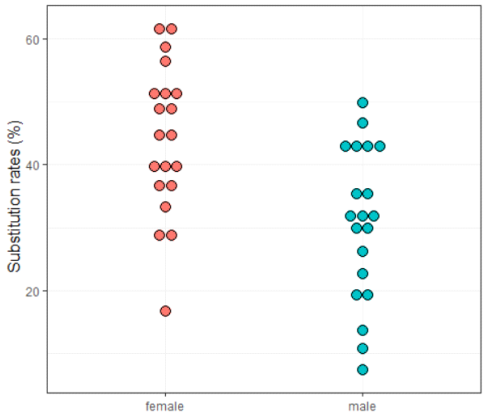

Figure 2. Distribution of the [u] substitution rates (%) of individual speakers by gender

As for the age group comparisons, Table 2 depicts the frequencies of occurrence and substitution rates of [o] and [u], which are surface forms of the underlying form /o/, for different age groups whereas Figure 3 reveals the distribution of [u] substitution rates for different age groups. Altogether, 40 speakers participated in this study, with five men and five women from each age group. As shown in the leftmost cell of Table 2, the numbers of tokens in the underlying form of /o/ varied as 40s > 30s > 20s > 10s. The data in the rightmost cell, which expressed the above aspect in substitution rates (%), show that the substitution rates for the phonetic form of [u] for different age groups were 40s> 30s> 10s> 20s.

Table 2. Frequencies of occurrence and substitution rates of [o] and [u] by age group

Number of Tokens	Phonetic Form	Frequency	Rate (%)
10s	o	2,393	56.4
(*n*=4,241)	u	1,848	43.6
20s	o	3,335	61.4
(*n*=5,435)	u	2,100	38.6
30s	o	3,603	55.6
(*n*=6,484)	u	2,881	44.4
40s	o	2,979	45.5
(*n*=6,542)	u	3,563	54.5

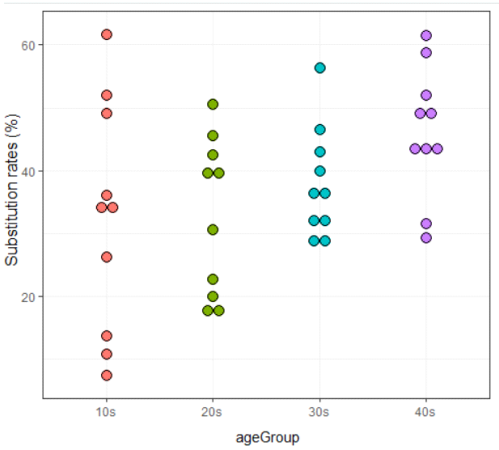

Figure 3. Distribution of the [u] substitution rates (%) of individual speakers for different age group

Table 3 depicts the data that divided the aforementioned details by gender and age groups to examine the differences. The group with the highest substitution rate was women in their 40s (52.9%), which was followed by women in their teens (46.5%), men in their 40s (39.5%), and women in their 20s (38.5%) in that order. The group with the lowest substitution rate was the group of teenage men (18.7%).

Table 3. Substitution rates (%) of [o] to [u] by gender and age group

Gender	Age Group	N. of Speakers	Min.	Max.	Ave.	*SD*
Female	10s	5	33.3	61.7	46.5	11.7
	20s	5	16.8	50.5	38.5	12.9
	30s	5	28.4	56.4	38.3	11.3
	40s	5	43.9	61.5	52.9	7.2
Male	10s	5	7.5	35	18.7	11.6
	20s	5	18.6	42.5	26.9	9.9
	30s	5	31.8	46.6	37.9	6.6
	40s	5	29.3	49.8	39.5	8.7

Figure 4 diagrammatically represents Table 3 data. As shown in the figure, the substitution rate of [u] among female speakers was higher than that of their male counterparts for all age groups. Interestingly, the occurrences of phonetic variations increase among older age groups. In other words, the substitution rate decreased for younger age groups among male speakers. Three out of five male teenagers had a substitution rate of less than 15%—the lowest scores among 40 subjects.

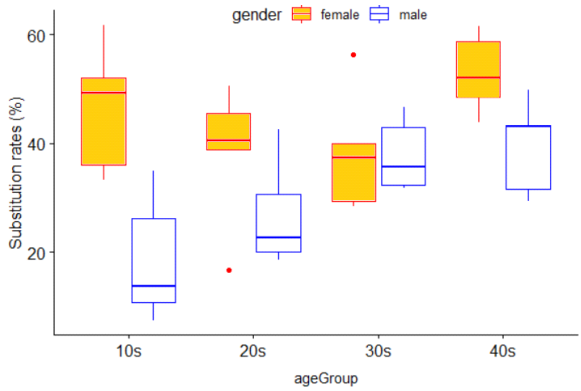

Figure 4. Comparison of the [u] substitution rates (%) among speakers' gender and age group

Two-way analysis of variance (ANOVA) using the statistical program R (ver. 3.6.3) was performed to examine the statistical significance of the differences in the [u] substitution rate by gender and age group. Gender and age groups were

entered as independent variables, and the [u] substitution rate was entered as a dependent variable. First, the results of the equal variance (F=0.193, p>.05) and normality (w=0.975, p>.05) tests were found to satisfy both criteria. Consequently, as shown in Table 4, there was a statistically significant difference in the [u] substitution rate according to the gender [F(1, 3)= 16.993, p<.001]. There were also statistically significant main effects across age groups [F(1, 3)= 3.950, p<.05]. Furthermore, the interaction effect between gender and age groups showed significant differences [F(1, 3)= 3.026, p<.05].

Table 4. Between-subjects effects of [u] substitution rates (%) by gender and age group

Source	Type III Sum of Squares	*df*	Mean Square	*F-value*	*Sig.*
Gender	1774.224	1	1774.224	16.993	.000***
Age group	1237.130	3	412.377	3.950	.017*
Gender x Age group	947.834	3	315.945	3.026	.044*
Error	3341.056	32	104.408		

Statistically significant differences are expressed as ***p<.001 and *p<.05.

With the appearance of interactions by gender and age group, post-test Tukey HSD was conducted to examine whether differences occurred in the [u] substitution rates between the groups. The test revealed statistically significant differences in women in their 40s and teenage men [F(6.46, 32)= -5.304, p<.001], which were the groups that showed the biggest differences as well; they were followed by teenage women and men [F(6.46, 32)= 4.302, p<.05], women in their 40s, and men in their 20s [F(6.46, 32)= -4.033, p<.05]. No difference was detected in any other group.

3.2 Acoustic analysis

3.2.1 Formant analysis

The F1 and F2 values of the vowel /o/ in the underlying form that was realized to the surface form of [o] and [u] were measured. As expected, the formant values were significantly different between women and men. Therefore,

the results of the formant values were presented separately. Table 5 depicts the formant values by age group in female speakers, and Table 6 depicts the values in male speakers.

Table 5. F1 and F2 values by age group in female speakers

Age Group	N. of Speakers	Phonetic Form	F1(Hz)		F2(Hz)	
			Mean	SD	Mean	SD
10s	5	o	298	28.3	1,231	82.9
	5	u	290	22.1	1,308	40.1
20s	5	o	313	22.8	1,276	76.5
	5	u	296	24.9	1,357	74.3
30s	5	o	286	35.2	1,259	54.2
	5	u	274	29.0	1,347	154.1
40s	5	o	315	19.8	1,226	17.5
	5	u	300	15.1	1,389	98.8
Average	20	o	303	27.7	1,248	61.6
		u	290	23.6	1,350	97.1

Table 6. F1 and F2 values by age group in male speakers

Age Group	N. of Speakers	Phonetic Form	F1(Hz)		F2(Hz)	
			Mean	SD	Mean	SD
10s	5	o	238	21.6	1,335	123.8
	5	u	222	20.6	1,458	164.7
20s	5	o	263	32.6	1,217	75.1
	5	u	245	28.7	1,409	127.6
30s	5	o	253	31.7	1,201	110.9
	5	u	255	32.5	1,357	60.2
40s	5	o	244	24.3	1,215	72.4
	5	u	247	24.7	1,400	83.6
Average	20	o	250	27.4	1,242	105.8
		u	242	27.7	1,406	112.8

As shown in Table 5, the averaged F1 value calculated for the female group was 303 Hz for [o], which is very similar to the value, 290 Hz, calculated for [u]. The F2 values were 1,248 Hz for [o] and 1,350 Hz for [u], that is, the F2 value of [u] is slightly greater than that of [o]. As shown in Table 6, the F1 value calculated in the male group was 250 Hz for [o], which is very similar to the value, 242 Hz, for [u] as well. The F2 values were 1,242 Hz for [o] and 1,406 Hz

for [u], that is, the F2 value of [u] is slightly higher than that of [o]. In other words, the mid vowel [o] in both groups appears to have moved upward as high as the [u] located in the high vowel to the extent that there are almost no differences in the height of the tongue. In addition, in terms of the backness of the tongue, it implies that [u] is located on the less posterior side compared to [o].

In order to examine whether the differences in formant values by vowel and age group were statistically significant, two-way ANOVA was conducted by separating the data based on gender. Vowels and age groups were entered as independent variables, whereas F1 and F2 values (Hz) were dependent variables. The F1 value of the female group was found to satisfy both criteria, which is evident from the equal variance test result (F=0.325, p>.05) and the normality test (w=0.984, p>.05). Consequently, as shown in Table 7, there was no statistically significant difference in F1 values according to vowel [F(1, 32)=2.374, p>.05], and there were no statistically significant differences according to age group [F(3, 32)=0.173, p>.05]. Furthermore, there was no significant difference in the interaction effect according to the vowel and age group [F(3, 32)=0.045, p>.05].

Table 7. Results of the between-subjects effect test of F1 value by vowels and age groups in the female group

Source	Type III Sum of Squares	*df*	Average Square	*F-value*	*Sig.*
Vowels	1651.2	1	1651.23	2.3742	0.1321
Age group	120.1	3	120.12	0.1727	0.6802
Vowel x Age group	31.2	3	31.2	0.0449	0.8334
Error	25037.4	32	695.48		

On the other hand, the F2 value satisfied both criteria as a result of the equal variance test (F=2.748, p>.05) and normality test (w=0.983, p>.05). As shown in Table 8, the results of two-way ANOVA revealed a statistically significant difference in the F2 value by vowel [F(1, 32)= 15.836, p<.001]; however, no statistically significant effect occurred by age group [F(3, 32)=0.770, p>.05]. Furthermore, there was no significant difference in the interaction effect by vowel and age group [F(3, 32)=1.309, p>.05].

Table 8. Results of the between-subjects effect test of F2 value by vowels and age groups in the female group

Source	Type III Sum of Squares	*df*	Average Square	*F-value*	*Sig.*
Vowels	104448	1	104448	15.8362	0.000***
Age group	5080	3	5080	0.7703	0.386
Vowel x Age group	8633	3	8633	1.3089	0.260
Error	237440	32	6596		

Statistically significant differences are expressed as $^{***}p<.001$ and $^{*}p<.05$.

The results of the equal variance test (F=0.478, p>.05) and the normality test (w=0.960, p>.05) for F1 values of the male group were found to satisfy both the criteria. Hence, as shown in Table 9, there was no statistically significant difference in F1 values by vowel [F(1, 32)=0.666, p>.05]. Additionally, no statistically significant differences were evident by age group [F(3, 32)=1.656, p>.05]. Moreover, there were no significant differences in interaction effect by vowel and age group [F(3, 32)=0.428, p>.05].

The results for the F2 values of the equal variance test (F=1.235, p>.05) and normality test (w=0.958, p>.05) satisfied both the criteria. As shown in Table 10, statistically significant differences [F(1, 32)=23.359, p<.001] in F2 values occurred by vowel in the two-way ANOVA. However, there was no statistically significant effect with age [F(3, 32)=2.218, p>.05]. Furthermore, there was no significant difference in the interaction effect between vowel and age [F(3, 32)=0.211, p>.05].

Table 9. Results of the between-subjects effect test of F1 value by vowel and age group in the male group

Source	Type III Sum of Square	*df*	Average Square	*F-value*	*Sig.*
Vowel	504.100	1	504.100	.666	0.421
Age group	3761.700	3	1253.900	1.656	0.196
Vowel x Age group	971.700	3	323.900	.428	0.735
Error	24235.600	32	757.363		

Table 10. Results of the between-subjects effect test of F2 value by vowel and age group in the male group

Source	Type III Sum of Square	*df*	Average Square	*F-value*	*Sig.*
Vowel	270109.225	1	270109.25	23.359	.000***
Age group	76956.475	3	25652.15	2.218	0.105
Vowel x Age group	7327.475	3	2442.49	.211	0.888
Error	370035.600	32	11563.613		

Statistically significant differences are expressed as $^{***}p<.001$ and $^{*}p<.05$.

Figure 5 summarizes the average formant values within 1 standard deviation (colored areas indicate female speakers).

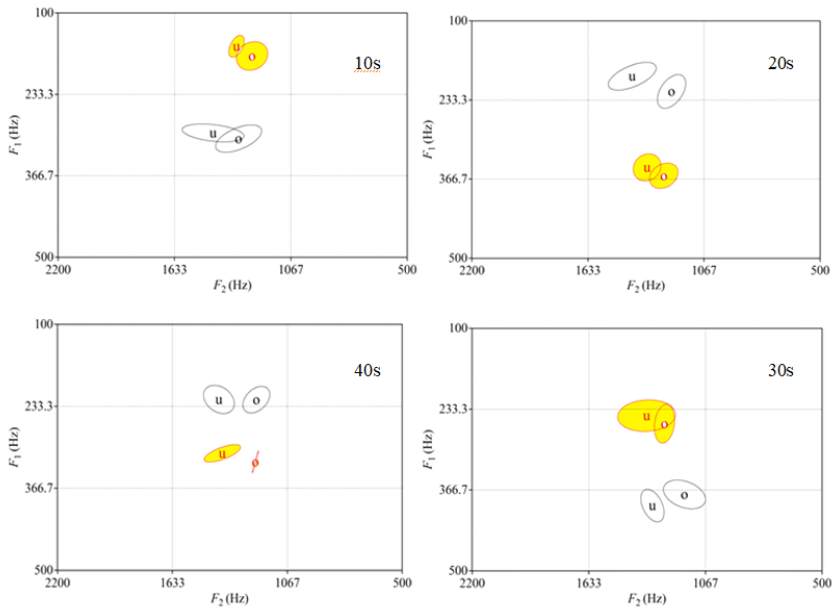

Figure 5. Comparison of vowel spaces by gender and age group (clockwise from top left; colored areas indicate female group)

It is interesting to note that the degree of proximity of the two vowel spaces appeared to differ across age groups. Both teenage girls and boys demonstrated that the two vowels are close enough to share vowel spaces of [o] and [u]. In

women in their 20s and 30s, both the [o] and [u] vowels were located close to each other, as for the teenagers. In comparison, there were differences in the F2 values for men in the same age groups. Both groups revealed greater differences in the backness of the tongue, rather than the height of the tongue. Further, the F1 values of [o] and [u] were similarly high in men and women in their 40s, and although there were differences in the F2 values, the vowels were spaced farther apart compared to the other age groups.

In Figure 6, to closely examine such differences, the average F2 values were separated by gender even though the statistical differences were not found. A major difference can be identified in the F2 value. In particular, the phonetic distances of the F2 values of those in their teens between [o] and [u] are shorter than other age groups for both genders. There is a clear tendency for the F2 value of [o] pronounced by men to increase with decreasing age, and a similar pattern is evident among women as well, (except for females in their teens), which means that the [o] located at the back relatively shifts forward with age.

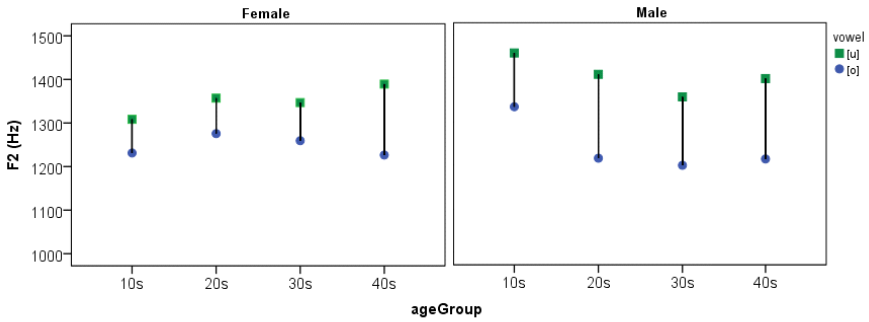

Figure 6. F2 values of [o] and [u] by gender and age group

3.2.2 Euclidean distance between [o] and [u]

The Euclidean distance between [o] and [u] by gender and age group was measured, and Table 11 summarizes the results. Women were found to pronounce shorter Euclidean distance, since the results showed d_{ou} =116 Hz for women and d_{ou}=166 Hz for men. In addition, based on the average value shown in Table 11, the average Euclidean distance was longer in men since men in

their 20s > men in their 40s > women in their 40s > men in their 30s were the top four groups with the highest Euclidean distances. The Euclidean distance decreased in the following order: men in their teens > women in their teens > women in their 30s > women in their 20s.

Table 11. Descriptive statistics of the Euclidean distance between [o] and [u] by gender and age group

Category	Age Group	Number of Speakers	Min.	Max.	Mean	SD
Female	10s	5	15	176	109	64.8
	20s	5	69	122	83	22.6
	30s	5	16	321	107	124.2
	40s	5	87	284	164	89.9
	Average				116	75
Male	10s	5	24	225	126	86.2
	20s	5	86	257	194	68.6
	30s	5	38	247	157	83.2
	40s	5	22	374	185	151.9
	Average				166	97

Figure 7 depicts a difference in Euclidean distance according to gender and age. In the box plot, the Euclidean distance between [o] and [u] appears longer for women than men and for older than younger age groups. It confirms that women in their 20s generally produce shorter pronunciation between the two vowels; furthermore, the distribution of Euclidean distances for women in their 40s varied considerably.

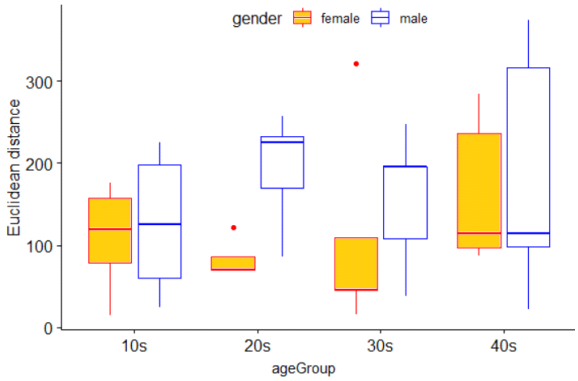

Figure 7. Comparison of Euclidean distance between [o] and [u] by gender and age group

Two-way ANOVA was conducted on the Euclidean distance by gender and age group to determine whether there was a statistically significant difference. First, the results of the equal variance test (F=0.755, p>.05) and normality test (w=0.975, p>.05) were found to satisfy both criteria. As shown in Table 12, two-way ANOVA did not show any statistically significant difference in terms of gender [F(1, 32)=2.801, p>.05] or statistically significant effect according to age group [F(3, 32)=0.655, p>.05]. Moreover, there was no significant difference in interaction effect according to gender and age group [F(3, 32)= 0.534, p>.05].

Table 12. Results of the between-subjects effect test of Euclidean distance by vowel and age group

Source	Type III Sum of Square	*df*	Average Square	*F-value*	*Sig.*
Vowel	24601.600	1	24601.600	2.801	0.104
Age group	17246.200	3	5748.733	0.655	0.586
Gender x Age group	14065.400	3	4688.467	0.534	0.662
Error	281037.200	32	8782.413		

The Tukey HSD test was performed to precisely examine the differences between groups; however, statistical differences did not occur.

4. Discussion

This corpus-based study examined sub-phonemic variants [o] and [u] of the phoneme /o/ concerning /o/-raising, across gender and four different age groups from teenagers to subjects in their 40s.

First, it attempted to identify [u] substitution rates for [o]. The occurrence of [o] and [u] in the derived forms of the phoneme /o/ was examined in word-final positions. It was confirmed that [u] substitution rates appeared at a higher rate in women than men. In terms of age group, the [u] substitution appeared to be higher in subjects in their 40s compared to teenage participants. The higher frequency of phonetic variation by women than men was consistent with the results of earlier studies (Kang and Kong 2016; Kang and Han 2013). However, contradictory results were observed for age groups in that younger age groups appear to speak with more standard pronunciations than older age groups.

To more precisely examine how this result happened, each individual's result needs to be examined. It is unclear whether good performance is a characteristic of individual speakers—notably, three out of five boys in their teens had the lowest scores among 40 participants—or the interview environment. Interview contents may vary depending on the social status or power difference between the interviewer and interviewee. In order to identify this phenomenon more precisely in Korean, data should be extracted from more natural, spontaneous speech in the future. It is less easy to draw clear conclusions about the younger speakers' linguistic behaviors.

Secondly, the direction of change was identified from the results of analyzing the F1 and F2 formant values of [o] and [u]. Statistically significant differences occurred in F2 values regardless of gender and age, but not in F1 values. This finding confirmed that in the F1 × F2 vowel space, the two vowels were very closely positioned in terms of vowel height. The most interesting aspect of this study was that the phonetic spaces of [o] and [u] is getting closer in younger age groups for both genders in terms of the backness of the tongue (within 1 standard deviation). Predictions were made regarding the direction of vowel shift. It was confirmed that the sub-phonemic variant [o] is raised upward to [u], and cross-generational differences were found in the tendency of [o] to move

inward to the center in most cases. This suggests the need to examine the influence that may be exerted by a vowel shift on the phonetic value of [u].

Finally, women had a relatively shorter Euclidean distance than men, and a comparison of teenage subjects to subjects in their 40s showed that the teenagers had a relatively shorter Euclidean distance in terms of the distance's distribution, although a significant statistical difference was not found. Similar results were obtained for the Euclidean distance becoming shorter for younger age groups in the study by Byun (2018) and Kang and Han (2013).

5. Conclusions

This corpus-based study attempted to identify gender and age differences in sub-phonemic variants of /o/ in Korean spontaneous speech. It is commonly believed that women are innovators for language change (e.g. Eckert 1989; Labov 1991). This study confirmed that women responded more sensitively to language changes of /o/ in word-final positions. The substitution rates of [u] for women occurred at a higher rate than for men. However, in terms of age group, the substitution rates of [u] occurred at a higher rate in the older age group than in the younger age group, which is not consistent with the earlier studies (Kang and Han 2013; Kang and Kong 2016).

Although substitution rates of [u] were lower for younger age groups, it was found that the Euclidean distance between the two vowels was shorter with younger age for both men and women, although no statistically significant differences were observed. It turned out that once the younger speakers substituted [u] for [o], the phonetic realizations of [o] and [u] were located closer in the phonetic spaces compared to other age groups.

The distinction between the two vowels is not determined only by the change of the F1 values, but is realized differently by the change of the F2 values, which is consistent with the earlier studies (Kang 2014; Yoon and Kim 2015; Lee et al. 2016; Lee et al. 2017). The current study was, in particular, interested in the acoustic properties of [o] or [u], which are derived forms of the phoneme /o/. What is noteworthy about this study is that the result of the acoustic analysis showed that [o] and [u] are close enough to share their

phonetic spaces with backness of the tongue as well as tongue height with a decrease in the ages of both men and women, which means that [o] moves upward and inward to the central vowel in the phonetic space. This cross-generational difference provides robust evidence for /o/-shift in contemporary Korean. In addition, this finding suggests the need to further observe the progress of /u/ triggered by the /o/-raising.

References

Byun, Hi-Gyung. 2018. Acoustic parameters that differentiate /o/ from /u/ in Seoul Korean. *Phonetics and Speech Sciences* 8(4): 25-31.

Chae, Seo-Young. 1999. The core-periphery structure in the Korean lexicon reflected in a phonological variation and change. *Studies in Phonetics, Phonology and Morphology* 5(1): 217-236.

Eckert, Penelope. 1989. The whole woman: Sex and gender differences in variation. *Language Variation and Change* 1(3): 245-267.

Eychenne, Julien and Léa Courdès-Murphy. 2019. Phonometrica: An open platform for the analysis of speech corpora. *Proceedings of the Seoul International Conference on Speech Sciences* 2019, 107-108. Seoul: Seoul National University.

Ha, Young-Woo and Jeahyuk Oh. 2017. A study on vowel systems and aspects focusing on announcers' vowel pronunciation. *Studies in Phonetics, Phonology and Morphology* 23(1): 55-94.

Han, Jeong-Im and Hyunsook Kang. 2013. Cross-generational change of /o/ and /u/ in Seoul Korean I. *Speech and Science* 5(2): 25-31.

Homles, Janet. 2013. *An introduction to sociolinguistics* (4th edition). New York: Routledge.

Jang, Hyejin and Jiiyoung Shin. 2007. Gender difference of standard language orientation throughout the monopthongs by 20's Daegu Dialect Speakers. *Korean Linguistics* 36: 289-314.

Kang, Hui-suk. 2014. The intervention of linguistic policy in sound changes and novel language: Focusing on a sound change from 'o to u' in words used in the Seoul area. *The Sociolinguistic Journal of Korea* 22(1): 1-21.

Kang, Hyunsook and Jeong-Im Han. 2013. Cross-generational change of /o/ and /u/ in Seoul Korean II: Spectral interactions in normalized vowel space. *Speech and Science* 5(2): 33-41.

Kang, Jieun and Eun Jeong Kong. 2016. Static and dynamic spectral properties of the

monophthong vowels in Seoul Korean: Implication on sound change. *Phonetics and Speech Sciences* 8(4): 25-31.

Kang, Yoonjung. 2014. A corpus-based study of positional variation in Seoul Korean vowels. *Japanese/Korean Linguistics* 23: 1-20.

Kwon, Yunjung. 2009. A study on vowel raising in contemporary Korean. MA Thesis. Korea University.

Labov, Williom. 1990. The intersection of sex and class in the course of linguistic change. *Language Variation and Linguistic Change* 2: 205-251.

Lee, Hyangwon, Woobong Shin, and Jiyoung Shin. 2017. A sociophonetic study on high/mid back vowels in Korean. *Phonetics and Speech Sciences* 9(2): 39-51.

Lee, Ju Hee, Kyu Chul Yoon, and Koon Hyuk Byun. 2016. A study of vowel shift in Seoul Korean. *Journal of Studies in Language* 31(4): 979-998.

Moon, Seung-Jae. 2007. A fundamental phonetic investigation of Korean monophthongs. *Malsori* 62: 1-17.

Paek, Doo Hyun. 1988. Opposition relation of 'Are-a(/ㅇ/), o, ɨ, u' and labialization. *Journal of Korean Linguistics* 17: 177-202.

Yang, Sun-Im. 2018. A critical review on the studies of the Korean monophthongs: At the contact point of Korean educational linguistics. *Journal of Korean Linguistics* 85: 429-462.

Yoon, Eunkyung. 2020. Frequency of grammar items for Korean substitution of /u/ for /o/ in the word-final position. *Phonetics and Speech Sciences* 12(1): 33-42.

Yoon, Kyuchul and Soonok Kim. 2015. A comparative study on the male and female vowel formants of the Korean corpus of spontaneous speech. *Phonetics and Speech Sciences* 7(2): 131-138.

Yun, Weonhee, Kyuchul Yoon, Sunwoo Park, Juhee Lee, Sungmoon Cho, Ducksoo Kang, Koonhyuk Byun, Hyeseung Hahn, and Jungsun Kim. 2015. The Korean corpus of spontaneous speech. *Speech and Science* 7(2): 103-109.

Eunkyung Yoon
Associate professor
Dept. of Korean Language and Multi-cultural Studies
Daegu Cyber University
Daegudae-ro 101, Jillang-eup, Gyungsan-shi, Gyungbuk 38453, Korea
E-mail: heavynub@dcu.ac.kr

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