

The Vowels of Cheju*

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Cho, Taehong^{1,2}, Jun, Sun-Ah¹, Jung, Seung-Chul³ & Peter Ladefoged¹. 2001. *The Vowels of Cheju*. *Korean Journal of Linguistics*, 26-4, 801-820. This paper investigates acoustic qualities of monophthong vowels of Cheju spoken by rural and urban speakers mostly in their 60 - 70s. We examined the first and second formants (F1 and F2) of vowels with reference to how vowels are spaced in the bark scaled vowel space. One of the obvious findings is that quite a few Cheju speakers do make clear distinctions between *e* and *æ*, and *o* and *ʌ*. When the urban and rural data were considered separately, and were compared with those about 50 years ago, a few generalizations appear to fall out: (1) the mergers of *e/æ* and *o/ʌ* are in progress in Cheju; (2) the mergers spread from the urban to the rural area; (3) the *e/æ* merger started earlier than the *o/ʌ* merger; and (4) at least for the urban Cheju speakers, the merger is best accounted for by the merger-by-transfer model, a unidirectional change in which one phonemic category becomes another (cf. Labov, 1994). Further, when our data are compared with other acoustic data available (including studies of the standard Korean in the 1960s and 1990s), it suggests that the directionality of the diachronic sound change is guided by both auditorily and articulatorily based principles such as contrast maximization and effort minimization principles. (¹University of California, Los Angeles, ²Max-Planck-Institute for Psycholinguistics, ³Inha University)

1. Introduction

Cheju is the form of Korean spoken on Cheju Island, one of the nine provinces of the country. Although Cheju is not mutually intelligible with Standard Korean, it has been considered to be one of the six dialects in South Korea. In this paper we will take no stand on whether Cheju is a dialect of Korean or a separate language. Our purpose here is simply

* We thank Dr. Doheung Ko for providing us with the paper by Kim (1980), and Dr. Kee-Ho Kim for the paper by Lee, Kim, and Hong (1997). We also thank Dr. Chang-Myong Oh who helped us record in Cheju city, and Dr. Won-Bo Kim who helped us record in the rural areas and provided information of Cheju morphology. We are also grateful to all the Cheju speakers who recorded data for us.

to compare the vowels of Cheju with those of what we will refer to as Korean, meaning Standard Korean as spoken in Seoul. It is generally agreed that Cheju is currently in the process of changing from a 9 vowel system to a 7 vowel system, as shown in Figures 1a and b. The 9 vowel system is found in the dialect of the older generation of Cheju speakers, and the 7 vowel system is found in the dialect of the younger generation (Kim 1963, Hyeon 1964a, 1985, Jung 1995).

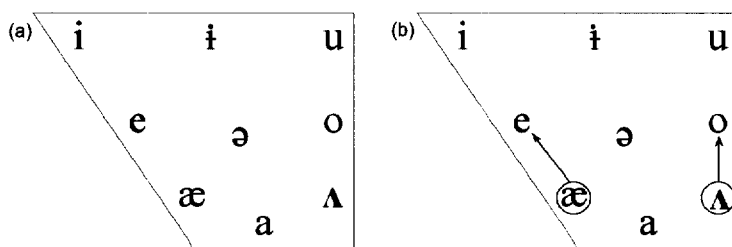


Figure 1. Two vowel systems in Cheju. The 9 vowel system in (a) is found in the older generation and the 7 vowel system in (b) is found in the younger generation (Jung 1995).

Historically, in Middle Korean, ʌ (known as *alae* a 'below a,' named after its location in the old hangul paradigm) contrasted with *o* in rounding and in vowel height (Jung 1995), but it disappeared in Standard Korean in the late 1800s (Lee 1972, Huh 1980). (Note that the symbol ʌ is used to refer to the unrounded counterpart of *o* simply for the sake of simplicity, but its exact phonetic values in the vowel space may not correspond to those of ʌ in the IPA vowel chart.)

In Cheju, however, it has been claimed that ʌ has not been completely lost, and still contrasts with *o* in the speech of the older generation of Cheju speakers, as exemplified by the minimal pair *tol* 'rock' and *tʌl* 'moon' (Jung 1995). The presence of ʌ in the speech of these speakers would allow us to have some insight into the nature of this sound in middle Korean.

The other vowel that exists in the 9 vowel system but not in the 7 vowel system in Cheju is the mid-low or low front vowel *æ*, which is sometimes transcribed as *ɛ*. In this paper, we will use *æ* for this mid-low front vowel, noting, however, that we are not suggesting that

this vowel is the equivalent of the English vowel 'a' as in 'apple' which is often transcribed with the symbol æ. The merger of e and æ is in progress in Cheju Korean (Jung 1995), and this is believed to be also true in Seoul Korean (Hong 1991, Kang 1996).

The phonetic structures of Cheju vowels have not been intensively studied. The only acoustic study that we have found in the literature is by Kim (1980). Kim reported F1 and F2 values of vowels in various phonetic contexts from one male speaker, 80 years of age at the time of recording in 1969. The speaker had not been exposed very much to (Seoul) Korean. The average values of F1 and F2 for monophthong vowels as reported by Kim are plotted in Figure 2, where the vertical axis shows F1 values and the horizontal axis shows F2 values in Hz. As can be seen in the figure, these vowels are quite symmetrically distributed in the F1-F2 plane, and there are clear differences between e and æ and between o and ʌ.

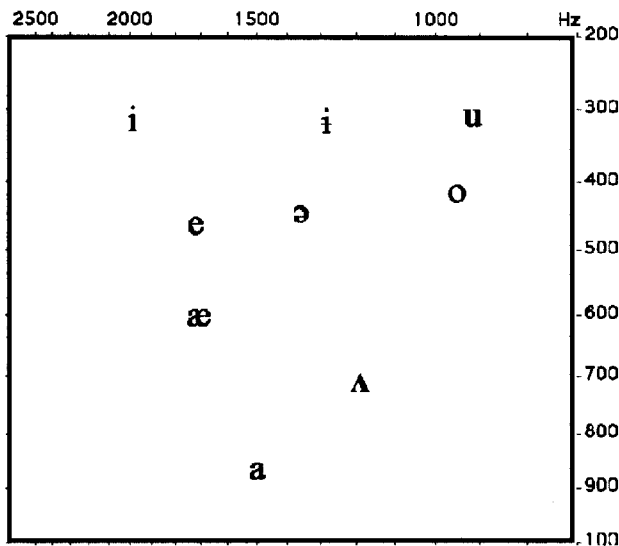


Figure 2. The formant values of 9 vowels produced by an 80 year old male speaker as of 1969. The formant values of each vowel are based on the mean values in H.-K. Kim (1980). The y-axis is F1 and the x-axis is F2.

2. Procedure

This paper is based on recordings of eight male speakers of Cheju. Three speakers (S1-S3), aged 55, 61 and 68, were recorded in Cheju city, and the other five speakers (S4-S8) were recorded in the more mountainous area of southern Cheju (Namcheju-kun), in two villages: Shinrye-ri and Uikwi-ri. The five men in this region were between 66 and 74 years old. All the speakers understood Korean, were literate, and above average in their socioeconomic status. Each of the eight speakers was recorded using a close-talking, noise-canceling Shure microphone and a Sony DAT recorder. Further details of the recording procedures are given in Cho, Jun and Ladefoged (2000), a paper discussing the consonants of Cheju based on data recorded at the same time (see also Cho, Jun and Ladefoged (in press)).

Table 1. Words recorded for the analysis of vowels in a word initial syllable.

(a) After velar stop

Vowel	Words in isolation	Speakers	Gloss
i	k* <i>i</i> əmtfə k* <i>it</i> fimalla	S1-S3 S4-S8	'to fit' 'don t fit it'
e	k* <i>e</i> əmtfə k* <i>et</i> fimalla	S1-S3 S4-S8	'to break (glass)' 'don't break it'
æ	kæəmsə kæt*fimalla	S1-S3 S4-S8	'to clear (sky)' 'don't fold (a blanket)'
i	k* <i>i</i> la	all	'to turn off (light)'
ə	kəlla(ke)	all	'to hang'
a	kalk*əjə	all	'to plow'
ʌ	kʌlla	all	'to grind (knife)'
o	k* <i>o</i> əmtfə k* <i>ot</i> fimala	S1-S3 S4-S8	'to twist (knot)' 'do not twist (knot)'
u	k* <i>u</i> əmtfə k* <i>ut</i> fi anjəttfə	S1-S3 S4-S8	'to dream' '(I) did not dream'

Table 1. Cont'd

(b) After denti-alveolar stop

Vowel	Words in isolation	Speakers	Gloss
i	t+i	all	'band (waist)'
e	tættfə t*etfimalla	S1-S3 S4-S8	'to get burned' 'do not take off'
æ	tættf tətfimalla	S1-S3 S4-S8	'to touch' 'do not touch'
i	tittfə	all	'to encumber money'
ə	t ^h ələttfə t ^h ələpulla	S1-S2 S3-S8	'to dust'
a	t ^h attfə	all	'to burn'
ʌ	tʌttfə	all	'to sew on a button'
o	tolattfə	all	'to go around'
u	tuəstfə tutfimalla	S1-S3 S4-S8	'to place' 'do not place'

(c) Front mid/low vowel pairs in monosyllabic words

Vowel	Words in isolation	Gloss
e	pe	'hemp cloth'
æ	pæ	'thick rope'
e	se	'tongue'
æ	sæ	'material (roof)'
e	k ^h e(ta)	'to chap'
æ	k ^h æ(ta)	'It is k ^h æ (game)'

The three sets of words used for the analysis of vowel quality in this study are shown in Table 1a-c, in a broad phonetic transcription, using the diacritic ‘*’ to mark fortis obstruents. The first set has vowels after a velar stop, the second after a denti-alveolar stop. The third set contains additional words suitable for the *e/æ* comparison. The third column in Table 1a and 1b indicates which speakers produced which words. Two different words were used for the vowels *i*, *e*, *æ*, *o*, *u* because the speakers from the rural area were not familiar with the words which were used by the speakers in the urban area (i.e., Cheju City).

Recordings were digitized into a computer at a sampling rate of 10 kHz. The first two formant frequencies were measured using the Kay Elemetrics MultiSpeech system. For each token, a steady state portion was found near the mid point of the vowel, and superimposed LPC and FFT spectra were calculated with 30 ms and 25.6 ms frames, respectively. The formant values were usually determined from the LPC spectra (with 12 or 14 coefficients), using the FFT spectra (and sometimes formant history tracking) as supplementary checks.

3. Results

Figure 3 shows the vowel distribution across speakers and consonants (*t* and *k*) in the plane of the first two formants of the vowels, plotted on a Bark scale, using the UCLA Plot Formants program. This program was also used to draw ellipses with a radius of two standard deviations along the axes of the first two principal components of the distribution. This plot appears to show that there is considerable confusion among these vowels. The vowel space between *e* and *æ* and between *o* and *ʌ* is substantially overlapped and there is a large variation for *u* in the F2 dimension. In what follows, we will examine the distribution of vowel space and the variability of front/back mid vowels and *u*, considering factors such as speaker, region, and segmental context. When we do so, it will be apparent that much of the confusion can be resolved.

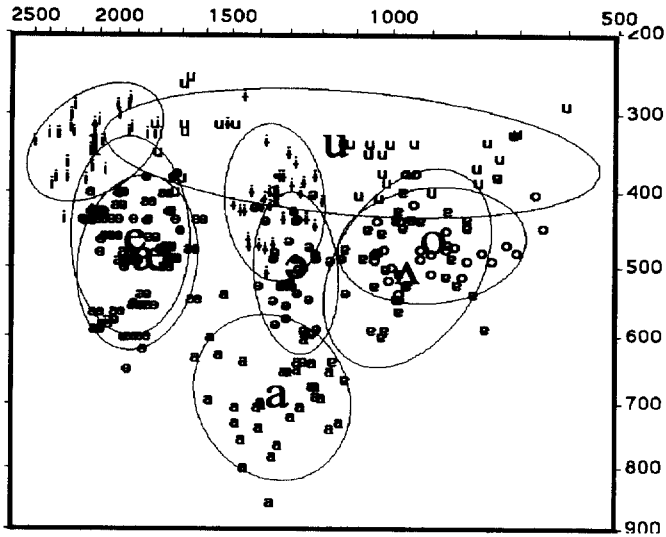


Figure 3. Formant plot of Cheju vowels across speakers and consonantal contexts. The y-axis is F1 and the x-axis is F2.

3.1 Front mid vowels: e and æ distinction

Part of the spread in the data for the e and æ vowels can be ascribed to a problem with the word list. The words **k**e*amtʃə** (recorded by the urban speakers) and **k**et*ʃimalla** (recorded by the rural speakers) are conventionally written in a way that indicates a pronunciation that might not correspond to their actual pronunciation. Since we followed such a convention in writing our word list, this might have caused confusions to Cheju speakers in mapping between Cheju sound and Korean orthography. On the other hand, the words containing the e and æ in /t_/ context were spelled, reflecting their pronunciation. Thus, we leave the words in /k_/ context out of our detailed analyses, focusing on the e and æ in /t_/ context.

In order to see whether there were differences between the urban and rural speakers, the data were submitted to a two way factorial ANOVA with factors Vowel, and Region. However, as Kirk (1995) noted, assumptions for the factorial model are less restrictive than repeated measures model, so in conducting the factorial analysis, the level of significance was set to $p < 0.01$ in order to counteract the relatively large

degree of freedom which may inflate the size of the effect, possibly causing Type I or alpha error. However, we report the case with *p*-values being less than 0.05 as a non-significant trend in order to make note of a tendency.

With the first formant (F1) as the dependent variable, there were significant effects for both factors ($F(1, 28)=12,085$, $p<0.001$ for the *e/æ* difference. But, there is only a trend for the Urban/Rural difference ($F(1, 28)=4.253$, $p<0.05$)). There is also a significant Vowel by Region interaction ($F(1, 28)=7.391$, $p<0.01$). For the second formant (F2), none of the factors had a significant effect. Since there is Vowel by Region interaction, and the Region influenced the vowel production to some extent, the vowels are plotted separated by Region in Figures 4a and 4b, for the urban speakers and the rural speakers, respectively.

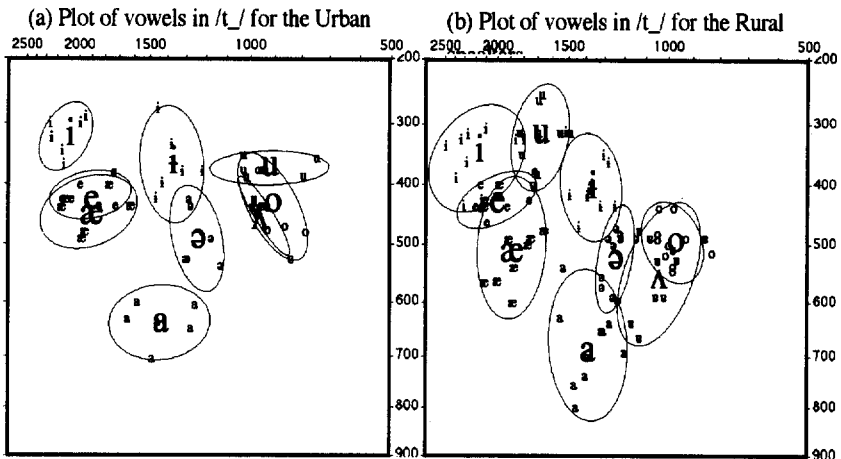
Pairwise posthoc comparisons show that urban speakers did not distinguish between *e* and *æ* in both F1 and F2, as seen in Figure 4a, while rural speakers did make a significant distinction between these two vowels in F1 ($p<0.0001$) as seen in Figure 4b—*æ* has a higher average F1 value than *e*, i.e., *æ* is a lower vowel than *e*. This asymmetry between Urban and Rural conditions appears to have given rise to the significant Vowel by Region interaction.

When we examine the formant values of *e* and *æ* in the monosyllabic words (Table 1c, Figure 6), it is clear that the rural speakers fully distinguish these two mid front vowels, but the urban speakers, even though they were in their 60's, do not. For the rural speakers, F1 is significantly greater for *æ* than for *e*, and has a similar value to that in the *æ* produced by the 80 year old speaker in 1969, as shown in Figure 2. However, our data suggest that even the rural speakers of Cheju do not make a distinction between *e* and *æ* as clearly as the distinction made 50 years ago.

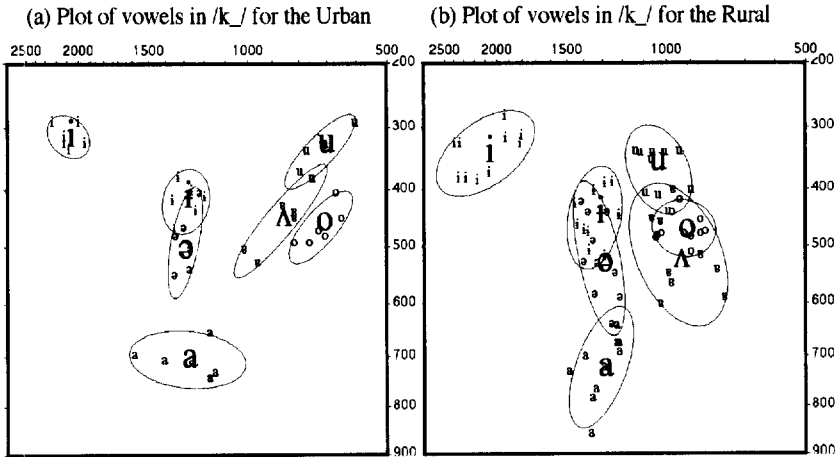
3.2 Back mid vowels: *o* and *ʌ* distinction

Figures 4 and 5 show that there is a difference between *o* and *ʌ* for both urban and rural speakers. The urban speakers make the *o/ʌ* distinction by employing an F2 (backness) difference. As can be seen in Figures 4a and 5a, they tend to make *o* less front than *ʌ*. This difference was significant only in the /k_/ context ($t=3.107$, $p=0.01$), but not in

the /t_/ context. On the other hand, the rural speakers make the o/ʌ distinction by employing an F1 (height) difference. As shown in Figures 4b and 5b, ʌ is generally lower than o and the differences are significant in the /t_/ context for all six speakers. In the /k_/ context, all but one speaker (S6) showed a significant difference in F1 ($t=2.522$, $p=0.0244$). It seems that this distinction is in the process of being lost among urban speakers, even those in their 60s, but is better preserved among rural speakers of a similar age, although one of the rural speakers did not show any difference at all again indicating a move towards a merger, even by the rural speakers. However, the distinction is not as clear as it was a half a century ago (see Figure 2 for the result reported in Kim, 1980). The rural speakers seem to lower the rounded mid back vowel, o, and raise and retract the unrounded vowel, ʌ, compared to the earlier data, thus weakening the contrast between these two vowels in both the height and the front/back dimension.



Figures 4. Formant plots of vowels in /t_/ context for (a) the urban speakers and (b) the rural speakers. The y-axis is F1 and the x-axis is F2.



Figures 5. Formant plots of vowels in /k_/ context for (a) the urban speakers and (b) the rural speakers. The y-axis is F1 and the x-axis is F2.

3.3 The variability of u

As noticed earlier in Figure 3, there is great variation in the distribution of tokens for **u**. A comparison of the four graphs in Figures 4 and 5 shows that rural speakers have more variation than urban speakers. In both speaker groups, **u** is fronter (i.e., higher F2 values) in *t_* context than *k_* context ($F(1,28)=17.532, p<0.001$), but the degree is much stronger in the rural speakers data. In addition, the frontness of **u** in each context is stronger in rural speakers' data than in urban speakers' data. Much of this variation is due to the coarticulatory effect of the adjacent segment. Figure 7(a) shows the effect of the preceding consonant on the formant value of **u** in two different following contexts (before **ə** in the left panel, and before **tʃi** in the right panel). The arrows indicate fronting of **u** when it is in *t_* context compared to when it is in *k_* context. In other words, speakers make **u** more fronted after the front consonant **t**, and such fronting is not made when the preceding consonant is **k**.

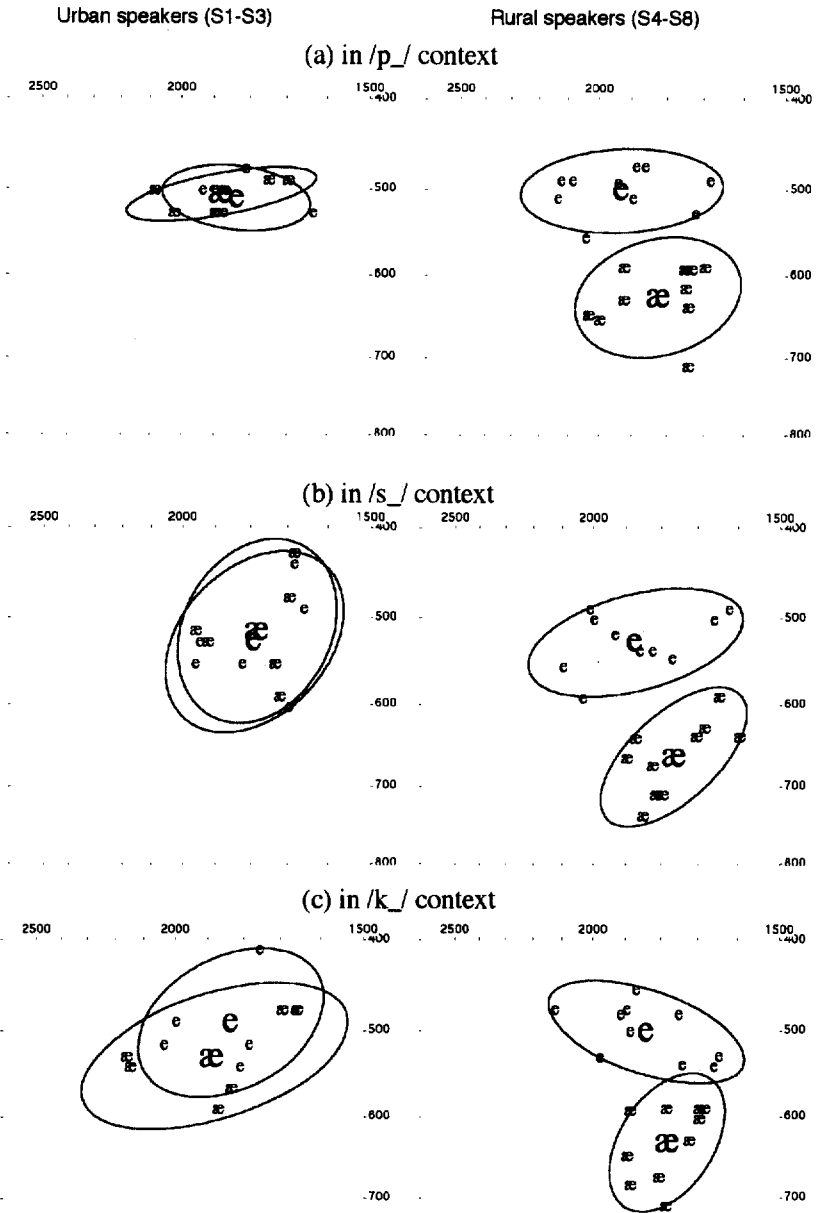


Figure 6. e/æ difference in monosyllabic words. The y-axis is F1 and the x-axis is F2.

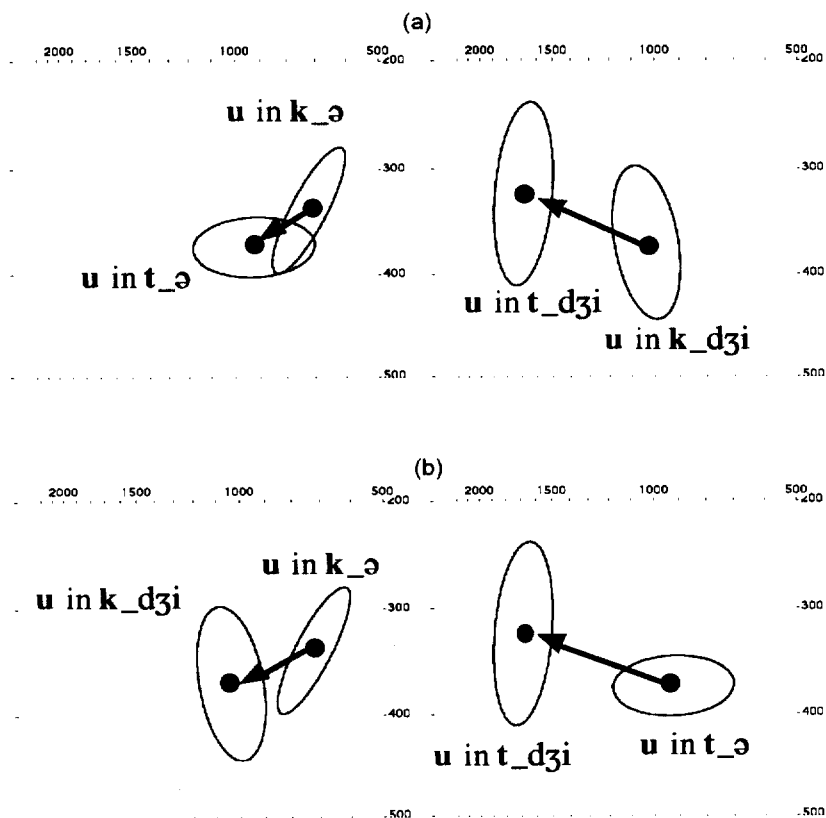


Figure 7. Variation of *u* due to the adjacent context, showing coarticulatory effect. (a) the effect of the preceding C on *u* and (b) the effect of the following V on *u*. The y-axis is F1 and the x-axis is F2.

In addition to the fronting due to the preceding context, the data also show that F2 values of *u* are influenced by the following context. The urban speakers produced *u* in words where the following context is ə as in *tuəttfə* ('to place') and *k*uəmtfə* ('to dream') while the rural speakers produced *u* followed by *tʃi* as in *tutʃimalla* ('do not place') and *k*utʃi anjəttfə* ('(I) did not dream'). This different context significantly influenced the production of *u*. Figure 7b illustrates that *u* is more fronted (with a greater F2) when followed by *tʃi* than when followed by ə, and this is statistically significant ($F(1,28) = 31.124, p <$

0.0001 for F2). This suggests a significant effect of anticipatory coarticulation between **u** and the following segment, and explains why rural speakers show more context effect in the F2 dimension than urban speakers. In sum, the variation of **u** is due to the coarticulatory effect of adjacent segments, and the difference between urban and rural speakers is not related to a regional feature, but is caused by different word sets. Our data show that in general other back vowels are also fronted by the following **tʃi** context, but the effect is especially large in **u**.

4. Summary and discussion

In this paper, we examined the vowel space of Cheju with a primary focus on **e/æ** and **o/ʌ** differences and the variation of **u**. There is strong evidence that the rural speakers have an **e/æ** distinction in their clear speech, whereas the urban speakers, even in their 60s, seem to have lost it entirely. Second, both groups make the **o/ʌ** distinction to some extent. The rural speakers made a consistent distinction in F1, and the urban speakers made a distinction in F2 for half of the data recorded. Third, we observed a great deal of variability for **u**, which is primarily due to coarticulatory effects.

Our data suggest that the mergers of **e/æ** and **o/ʌ** are in progress in Cheju. Such transitory status can be seen in that **e/æ** or **o/ʌ** distinctions were made by the rural speakers most of the time, but rarely by the urban speakers of a similar age. This is presumably because the rural speakers are more conservative, and, as a result, tend to preserve the contrasts. This is reminiscent of a case reported by Trudgill (1974) where a pattern of merger is detected around an urban center and spreads to the rural area. Labov (1994, p. 313) explains that dialect geography is one of the most powerful tools available for interpreting the past by means of data drawn from the present. In other words, by the investigation of the forms spoken in an isolated rural area, we could possibly infer what the old forms would be like. In fact, some of the **e/æ** distinctions made by our rural speakers are very similar to those made by the old speaker in Kim's 1969 study. In addition, the direct comparison between the present day urban speakers' data and the data in Kim's 1969 study shows that the merger is in progress.

Our data also suggest that the *e/æ* merger started earlier than the *o/ʌ* merger in Cheju. Urban speakers in our study completely lost the *e/æ* distinction but still partially preserve the *o/ʌ* distinction. A supporting example is that there is a complete overlapping for the *e/æ* pair while a clear *o/ʌ* distinction is made by the same urban speakers, as seen in Figure 5a. This supports the informal observation shared by the researchers of Cheju; it has been believed that in general the loss of *o/ʌ* distinction is found among speakers in their mid 50s and younger while the loss of *e/æ* distinction is found among speakers in their 60s and younger.

It is interesting to note that the order of merger in Cheju between these two pairs is the opposite of that in Standard Korean. In mainland Korean, the *o/ʌ* merger occurred in late 1700s (e.g., Lee 1972; Huh 1980), and the *e/æ* merger has been in progress in the past several decades (cf. Hong 1991). Jung (1995) posits that the loss of contrast in non-high front vowels (the *e/æ* merger) that is in progress in Standard Korean is driven by pressure from the system. With only two back non-low vowels (*u* and *o*, after the loss of *ʌ*) and three front non-low vowels (*i*, *e*, and *æ*), the system is losing the *e/æ* distinction to make the vowel system more symmetric. Along the same line, we could posit that in Cheju, the *e/æ* merger started first and the *o/ʌ* merger follows to make the vowel system symmetric. It is believed that Cheju lost the *e/æ* distinction earlier than mainland Korean due to the confusion in the mapping between sound and the standard orthography. That is, as mentioned earlier, the vowel *æ* symbol in Korean is sometimes mapped to Cheju *æ* and sometimes to Cheju *e*.

4.1 Mechanism of mergers

Now a question arises as to by what route two phonemes become one. Labov (1994, pp. 321-323) suggested three models to account for different kinds of mergers that have been observed in sound changes. The first type of merger processes is merger by approximation i.e., phonetic targets of two distinctive sounds are gradually approximated until they become non-distinctive. In this type we expect the two sounds are merged into an intermediate phonetic form. The second type of merger occurs by means of merger by transfer. This process is a unidirectional change

in which one phonemic category becomes another. In general, merger by transfer takes place when one form becomes a social prestige, being dominantly used in an established standard language. The last process is merger by expansion—i.e., the new phonetic space is expanded to range over phonetic spaces of two phonemes that are merged. In other words, the new phonetic space falls neither on an intermediate range (as in merger by approximation) nor on the phonetic space that belongs to either one of the phonemes that are merged (as in merger by transfer).

It is not entirely clear from the data available to us what kind of merger process is taking place in Cheju. On the one hand, the new phonetic space for the *e/æ* for urban speakers as seen in Figure 4a appears to be best accounted for by the merger-by-transfer model which predicts a unidirectional change. In other words, the phonetic space of *æ* seems to re-map to that of *e*. This can be more clearly seen in monosyllabic words in Figure 6. On the other hand, the *o/ʌ* merger show inconsistent patterns between urban and rural speakers. The merger in Figure 4a (as produced by urban speakers) fits into the merger-by-transfer model i.e., the tokens are clustered around the phonetic space for *o*. By contrast, the merger shown in Figure 4b (rural speakers) indicate that, although there is no complete merger, merger-by-approximation appears to be in progress, i.e., the phonetic space for *o* is relatively lowered. Though more systematic data are required to examine the exact mechanism of the merger that is in progress in Cheju, what emerges from the data available is that at least the merger for the urban speakers is best accounted for by the merger-by-transfer model.

In the next section we will examine vowel spaces in Seoul Korean and Cheju synchronically and diachronically, and discuss the sound change related to the principles of the maximal perceptual contrast and minimal articulation.

4.2 Dispersion theory and sound change

So far, we have compared the two pairs of mid vowels in Cheju at two time frames separated by about 50 years. In this section, we will examine the vowel system of Seoul Korean roughly at the same time frame as Cheju data, and compare Seoul Korean data with Cheju data. As the vowel system of Seoul Korean at the two time frames, we will use data

from Han (1963) and Yang (1996).

Middle Korean had Λ , as in present day Cheju. In late 1700s Seoul Korean lost Λ (Huh 1980) and now has an 8 vowel system, if they have $e/\text{æ}$ distinction, or a 7 vowel system, if not (Kang 1997). Figure 8 illustrates vowel systems of (a) Seoul Korean and (b) Cheju. Figure 8a compares the present day vowel system of Seoul Korean (Yang 1996) with that in 1960s (Han 1963), and Figure 8b compares the present Cheju data with Kim's (1980) Cheju data. Note that the Cheju data from the present study are pooled from both urban and rural speakers except for u which is based on urban speakers' data only, due to the extreme fronting of rural speakers' data influenced by the following segments (see section 3.3 and Figure 4b). As a result, both $e/\text{æ}$ and o/Λ distinctions are merged in the Present Study plot in Figure 8b.

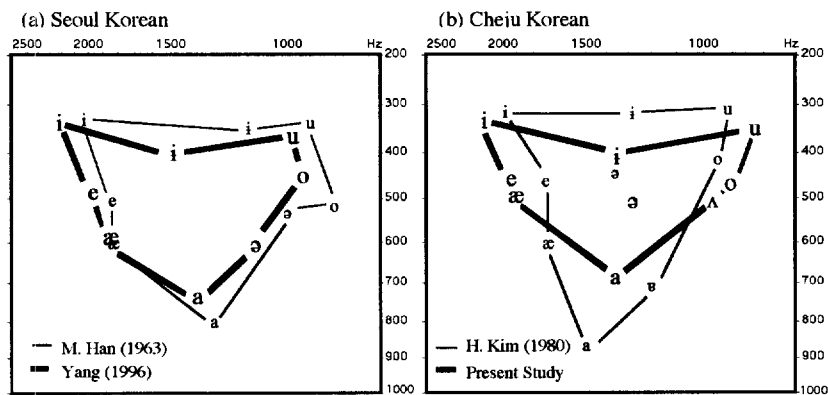


Figure 8. Comparisons between (a) Seoul Korean and (b) Cheju vowel systems at two time frames, current vs. 1960s. The vowel chart for Han (1963) was drawn based on her consultant 1's average values and Yang's (1996) data were based on 30 male Seoul speakers. The Kim (1980) data were collected in 1969.

In Figure 8a, there seems to be a clear distinction between $e/\text{æ}$ in Yang's (1996) data (the mean difference is 99 Hz in F2). However, the large standard deviations (75 Hz and 105 Hz for e and æ , respectively) suggests that the difference is not statistically significant. In fact, Lee, Kim, and Hong (1997) showed in their study of the vowel qualities of media language that there is no substantial difference between e and æ in the present day Seoul Korean. They also compared their own media data with Han's and Yang's data and showed that the vowel space is

smaller for the normally spoken media data, due to the reduction and the contextual influence. In sum, Seoul Korean had 8 vowels in 1960s (i.e., Han's data), and 7 vowels in 1990s (i.e., Yang's data), while Cheju had 9 vowels in Kim's study and 7 vowels (or 8 for rural speakers) in the present study.

Lindblom's revised dispersion theory (Lindblom 1986; Lindblom and Maddieson, 1988) predicts that, in a given system, contrastive vowels are spaced with a sufficient contrast. This principle of sufficient contrast can be observed in the location of the mid vowel ə and the low vowel a in Seoul Korean and Cheju. First, the vowel ə in Cheju is mid-central, whereas it is further back and lowered in Seoul Korean, taking the space of open-mid back vowels in the IPA chart (1999). This mid-centralness of the vowel ə is preserved in both the earlier and present day vowel systems of Cheju. We believe that this is due to the presence of contrast between ə against o or ʌ in Cheju. In Seoul Korean, on the other hand, it would not be necessary to keep ə in the central position. It seems that ə is instead moved to the open-mid back position, so that it could enhance the front/back contrast among vowels and make the system more symmetrical. That is, the comparison between Seoul Korean and Cheju allows us to infer that ə has been shifted from the central vowel space to the mid-back area in Seoul Korean, in order to achieve a sufficient contrast among vowels, a phenomenon in which the sound change is driven by the principle of contrast maximization.

Second, as shown in Figure 8b, within Cheju, a in the present study is much higher than that in Kim's study (by 139 Hz in F1). As discussed earlier, Cheju in 1960s had a 9 vowel system and had four vowels contrastive in vowel height, or F1 (e.g., i-e-æ-a or u-o-ʌ-a). This 9 vowel system seems to use a larger vowel space especially in the vowel height dimension, compared to the present Cheju vowel system in which there is a three way contrast in vowel height (i.e., i-e/æ-a or u-o/ʌ-a) due to the merger of e/æ and o/ʌ. Reducing the vowel space in the height dimension in the current Cheju system supports the sufficient contrast principle instead of the maximal contrast principle as originally proposed by Liljencrants and Lindblom (1972). The space reduction in the current Cheju system also supports the principle of articulatory effort minimization (e.g., Lindblom 1986, 1990; Flemming, 1995). These two principles together predict that speakers minimize the articulatory effort to an extent that allows a sufficient contrast. Our data follow these

principles. In the 9 vowel system, speakers make more effort to make an extreme **a**, or to open their mouth wider, in order to achieve a sufficient contrast between four vowels that are distinctive in vowel height, whereas in the 7 vowel system, speakers do not need to make such articulatory effort since less vowel space in height is required for sufficient contrast between three vowels. These auditorily and perceptually based principles together with the distribution and the inventories of the vowel system seem to guide the directionality of the diachronic sound change.

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