AN ACOUSTIC STUDY OF MONOPHTHONGS IN BRUNEI MANDARIN

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ABSTRACT

This study provides an acoustic analysis of the monophthongs of Brunei Mandarin. Recordings were made of a short text by 20 Bruneian Chinese as well as 20 Beijing Chinese. Comparison of the scatter plots show that [i] and [y] are merged in Brunei Mandarin. This observation is quantified by calculating the Euclidean distance between the minimal pair *nǐ* [ni] and *nǚ* [ny] and the frequency of F_3 of all open syllables with [i] and [y] in the text. The results confirm that [i] and [y] have a high degree of merger in Brunei Mandarin, while they tend to be distinguished in Standard Mandarin.

Keywords: Vowels; [i] and [y]; Brunei Mandarin; Standard Mandarin; vowel merger.

1. INTRODUCTION

Standard Chinese is a variety of Mandarin and its pronunciation is based on the Beijing dialect [3]. In China, Standard Chinese is generally codified in grammatical descriptions, dictionaries, and manuals of usage. Like any other language, Mandarin has many varieties, such as Taiwan Mandarin, Singapore Mandarin and Brunei Mandarin.

Brunei Mandarin refers to the variety of Mandarin spoken in Brunei, a small country located on the northern coast of Borneo. Approximately 11% of the population of Brunei are ethnically Chinese [2]. Nowadays, Brunei Mandarin is gradually developing a distinctive identity. For example, there is /t/ lenition in the 3rd person pronoun [13]; the neutral tone is less frequent compared with Standard Mandarin; rhotacization (*r*-suffixation) is absent, and the post-alveolar consonants are merged with the alveolar ones. There is also the possibility of vowel mergers.

A merger is a phonological process in which a distinction between two or more phonological categories is absent [8]. Vowel shifts and mergers in varieties of English have been widely documented, such as the THOUGHT-NORTH merger in British English [12], the FOOT-GOOSE merger in Scottish Standard English [9], and the LOT-THOUGHT merger in North American English [12]. However, not much work on vowel mergers has concerned varieties of Mandarin.

Vowel distributions of Mandarin in the F_1/F_2 plane were reported as early as in 1976 [5], but further research on vowel features is limited. For vowel mergers, it was briefly reported that in Taiwan Mandarin, the high front rounded vowel [y] is absent and is usually replaced by its unrounded counterpart [i] or high central vowel [ɨ] [8]. Although some degree of vowel overlap occurs in Beijing Mandarin, the vowels do not actually merge into each other when F_3 or phonotactics are taken into account [14].

In this study, the acoustic characteristics of monophthongs in Brunei Mandarin will be compared with those of Standard Mandarin by investigated the acoustic distribution of the vowels including a possible merger of [i] and [y].

2. METHODS

2.1. Subjects

40 tertiary students in Brunei and Beijing were recruited in this study, 10 females and 10 males in each country. At the time of the study, the Brunei speakers had a mean age of 21 years, ranging from 19 to 23 years, while the Beijing speakers had a mean age of 24 years, ranging from 20 to 30 years. Of the 20 Brunei speakers, 12 were from Universiti Brunei Darussalam (UBD), seven were from Institut Teknologi Brunei (ITB), and one was from Kolej IGS Brunei Darussalam (IGS), a private tertiary institution in Brunei. The 20 Beijing students were all from Beijing Language and Culture University (BLCU). Apart from two speakers from Beijing, the 18 others were from different provinces, i.e. Inner Mongolia, Heilongjiang, Jilin, Liaoning, Shandong, Henan, Hebei, Hubei, Guizhou and Zhejiang. They all speak standard Mandarin with little accent from their home dialect. In this study, we will label Brunei females, Brunei males, and females and males from China as BNF, BNM, CNF, CNM respectively.

2.2. Experimental task and stimuli

Recordings were conducted in a quiet office at UBD, ITB and BLCU using a high-quality microphone positioned a few inches from the mouths of the speakers. They read a passage called *The East Wind and the Sun* (the EWS text – see the Appendix), and

it was recorded directly onto a Sony laptop computer at a sampling frequency of 44,100 Hz.

In Mandarin, syllables can have a final nasal [3]. However, in this study, we will only consider open syllables, because a following nasal often interferes with the measurement of vowel formants [6].

This study will describe nine monophthongs in open syllables, using the transcription of Duanmu [3]: [i, y, u, e, o, ɤ, ɑ, z, ɻ]. [i, y, u] are three high vowels, while [e, o, ɤ] are the allophones of the mid vowel /ə/ that can occur in syllable final position. For example, [e] can be in syllable final position preceded by glide [j] or [ɥ], [o] can be in syllable final position preceded by [w], and [ɤ] can be in syllable final position in a CV syllable [8]. [ɑ] is the allophone of the low vowel /a/ that can be in syllable final position. In addition, there are two apical vowels [z] and [ɻ] that can occur in syllable final positions [3]. [z] only occurs after dental sibilants [ts, ts^h, s] and [ɻ] only occurs after retroflex sibilants [ʈs, $ʈs^h$, ʂ, ɻ] [7]. Although it is controversial whether they are vowels or not, they are still included because 1) they have clear formants and vowel-like articulation, 2) it is a common approach to include apical vowels in the F1/F2 plane to view their distributions in the literature of Mandarin.

All these vowels occur in the EWS passage though the number of tokens for each is not the same. Table 1 shows the syllables under investigation. Note that though some forms of Pinyin seem identical, they are not necessarily the same morphemes, as they may have tonal contrasts or they might be homophones.

Table 1: Vowels investigated in the EWS text.

Vowels	Syllables in EWS (in Pinyin)
[i]	*nǐ, jǐ, dì, lǐ, lì, bǐ*
[y]	*nǚ, yú*
[u]	*fú, fú, fú, fú, bù, bù*
[e]	*yě*
[o]	*shuō, pò, shuō, tuō, tuō, suǒ*
[ɤ]	*hé, hé, rè*
[ɑ]	*dà, mā, mā, tā, bǎ, dà, tā, tā, bǎ, lā, fǎ, tā, bǎ*
[z]	*zì, sì, sì*
[ɻ]	*shì, shí, shì, zhǐ, shì, shǐ, shì, shì*

There are 48 tokens for each speaker. However, when reading the passage, some speakers mispronounced one or two words. For example, *běnshì* /bənʂɻ̩/ ('skill') was mispronounced by one as [bənliŋ]. Furthermore, some Beijing speakers exhibited vowel reduction for syllables with the neutral tone, resulting some vowels without visible formants when inspecting the spectrograms. For example, *yīfú* /jifu/ ('clothes') was sometimes pronounced as [jifØ] in which [fØ] has a neutral tone and [Ø] represents the absence of a vowel. Nevertheless, at least 44 tokens were measured for each speaker.

2.3. Analysis

2.3.1. Scatter plot inspection

The first two formants (F_1 and F_2) were obtained in Praat [1] from the midpoint of each vowel. In order to show the distribution of vowel clusters clearly, scatter plots with ellipses were generated in R using the phonR package [10]. First, visual comparison of plots was made between Brunei females and Beijing females. Second, visual comparison of plots was made between Brunei males and Beijing males.

2.3.2. Euclidean distance

40 tokens of the minimal pair *nǐ* [ni] ('you') and *nǚ* [ny] ('female') in the EWS text were compared. The distance between the two vowels was measured by calculating the Euclidean distance on a Bark scale.

2.3.3. F_3 measurement

Though the F_1/F_2 plot provides a detailed representation of a vowel system, F_3 is also important in determining qualities such as retroflexion and rounding [4]. For rounded vowels such as [y], when the lips are protruded, the front cavity lengthens, yielding a lower F_2 and F_3. Since F_3 lowering has been shown useful in distinguishing [i] and [y] in French [11], this study also measures F_3 to further examine vowel mergers in Brunei Mandarin. As with the measurement of F_1 and F_2, the formant tracker in Praat was used to obtain the frequency of F_3 at the mid-point of tokens of [i] and [y] in the syllables shown in Table 1.

3. RESULTS

3.1. Formant analysis

Scatter plots for the two groups of speakers are displayed in Figures 1, 2, 3 and 4. Ellipses enclose 68% of the tokens of each vowel [10].

Figure 1 shows the vowel distributions of BNF. Nearly all the ellipses are clearly separated from each other except two pairs of highly overlapped close vowels: [i] / [y] and [z] / [ɻ]. To be precise, [i] and [y] almost completely overlap, while [z] and [ɻ] overlap substantially.

In contrast, in Figure 2, the vowels of CNF show less overlap between [i] / [y] and [z] / [ɻ], though there is some. In fact, there is some overlapping with all the vowels except [e] and [ɑ].

Figure 1: Scatter plot for BNF.

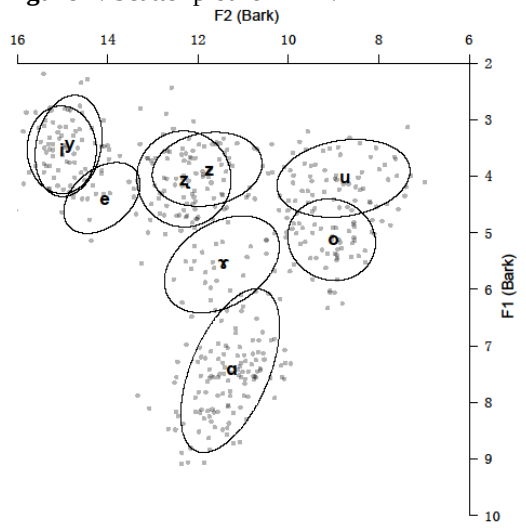
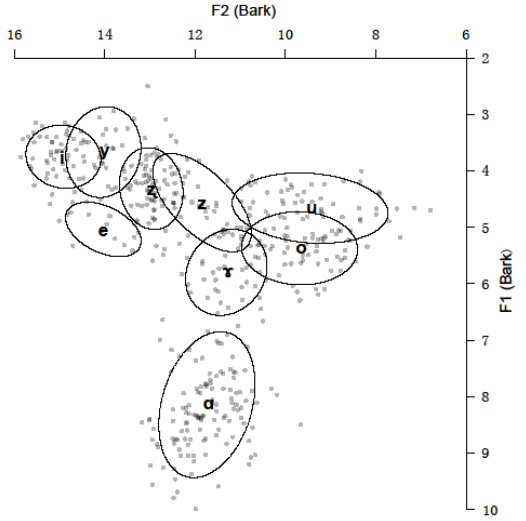


Figure 2: Scatter plot for CNF.



Figures 3 and 4 show the vowels of BNM and CNM respectively. The vowels in Figure 3 are all clearly separated except [i] / [y] and [z] / [ʐ], which show a high degree of overlap. Compared with BNM, the vowels of CNM are spread over a range of values in the F_1/F_2 plane, represented by expanded ellipses and greater overlaps, particularly for [u] / [o].

The visual comparison of the scatter plots indicates that Brunei speakers have two vowel mergers: [i] / [y] and [z] / [ʐ]. For the latter, it is well established that [z] occurs after alveolar consonants such as [s] as [ts] while [ʐ] occurs after post-alveolar consonants such as [ʂ] and [ʈs], so they might be regarded as allophones of the same vowel phoneme. The lack of a distinction between [z] and [ʐ] therefore represents a merging between the alveolar and post-alveolar consonants rather than a merging of vowel phonemes. We will therefore not consider it further here, and we will focus on the [i] / [y] merger.

Figure 3: Scatter plot for BNM.

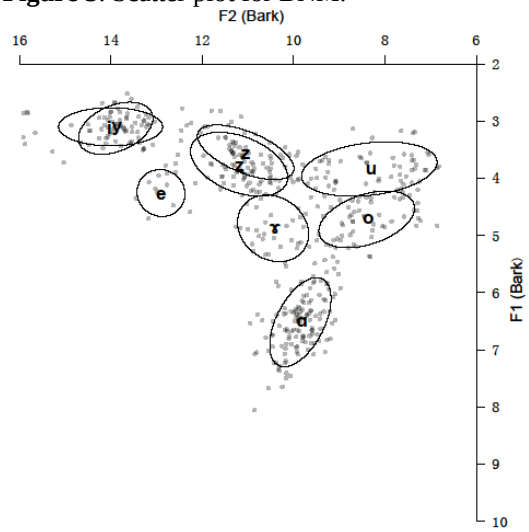
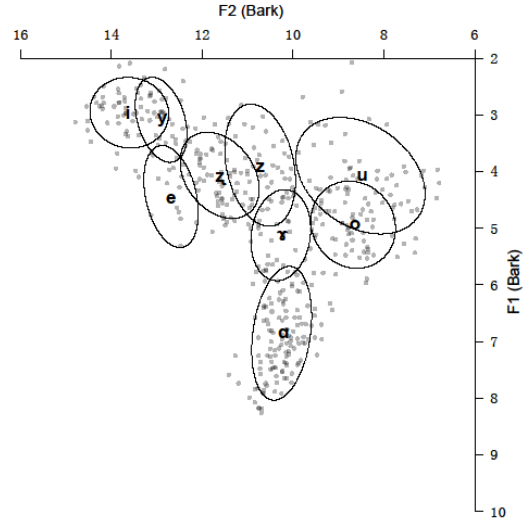


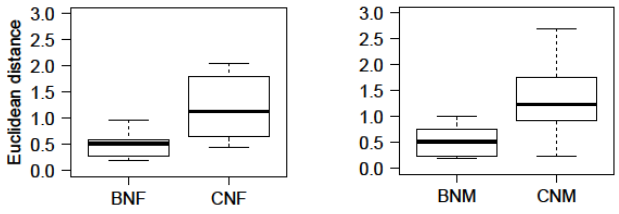
Figure 4: Scatter plot for CNM.



3.2 .Euclidean distance

Figure 5 shows the distribution of Euclidean distances on the Bark scale F_1/F_2 plot between [i] and [y] for the four groups of speaker.

Figure 5: Euclidean distance between [i] and [y].



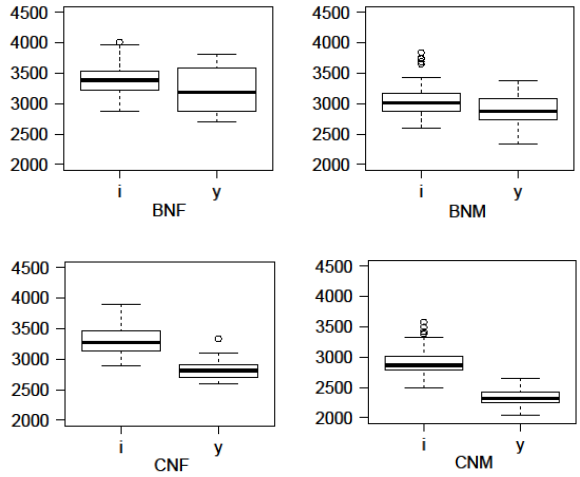
It can be seen that the Euclidean distance between [i] and [y] for the Brunei speakers tends to be much smaller than for the Beijing speakers, confirming that [i] and [y] in Brunei Mandarin tend to merge into the same phonetic space, while they are differentiated in Standard Mandarin. For the female speakers, the mean distance for the BNF speakers is 0.49 Bark, while for the CNF speakers it is signifi-

cantly greater at 1.18 Bark (t=3.40, df=39, p<0.01). For the male speakers, for the BNM speakers the mean distance is 0.52 Bark, while for the CNM speakers it is significantly larger at 1.32 Bark (t=3.42, df=39, p< 0.01).

3.3. F_3 measurement

The boxplots in Figure 6 show the average F_3 for [i] and [y] for the four groups.

Figure 6: Range of F_3 of [i] and [y]



Independent sample *t*-tests were conducted separately for each group, and the results are shown in Table 2.

Table 2: mean F_3 values for [i] and [y] (standard deviation is in brackets)

Group	[i] (Hz)	[y] (Hz)	*t*	*p*
BNF	3410 (233)	3226 (399)	1.95	ns
BNM	3061 (291)	2898 (283)	2.21	< .05
CNF	3309 (239)	2834 (187)	9.15	< .001
CNM	2904 (244)	2342 (143)	12.49	< .001

No difference was found between [i] and [y] for BNF, while the difference for BNM was marginally significant, suggesting that the male Bruneians may maintain a small distinction between [i] and [y]. However, the difference between [i] and [y] for CNF and CNM was highly significant, confirming that [i] and [y] occupy a distinct phonetic space in the Standard Mandarin of speakers in Beijing.

4. DISCUSSION AND CONCLUSION

In summary, speakers in Beijing tend to maintain a distinction between [i] and [y], while [i] tends to be merged with [y] in Brunei Mandarin. However, the directionality is not represented in the scatter plots or from the Euclidean distance, so it remains unclear whether [i] moves towards [y] or vice versa. Besides, it is uncertain what causes this vowel merger to occur. Further studies should probe these questions.

5. REFERENCES

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Appendix: *The East Wind and the Sun* (EWS) text

东风和太阳

一天中午，白云听见东风和太阳在那儿你争我吵，都说自己的本事大。这时，从森林的草地里来了一个老公公，一个妈妈和她的女儿，还有一个小王子，全身都穿着破旧的衣服。于是，白云说，只要谁能让这四个人把衣服脱下，就算谁的本事大。然后，东风就张开口，使劲儿地吹。但是，它刮得越用力，他们四个就把衣服拉得更紧。最后，东风累了，也没什么办法了。一会儿，轮到太阳了，他们一看见阳光，热得快快把衣服脱了下来。所以，东风不得不同意，还是太阳比较强。