Vowels and Diphthongs in Chengdu Mandarin

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ABSTRACT

This paper gives an acoustic phonetic analysis of the monophthongs and diphthongs in Chengdu Mandarin. Acoustic data suggest a typological difference between falling diphthongs and rising diphthongs. Rising diphthongs are sequences of vowels, since both onset and offset elements have comparable spectral targets as do their monophthongal counterparts. By contrast, falling diphthongs are dynamic units of vowels, since they are featured by the dynamicity rather than could be decomposed to a sequence of two spectral targets. In conclusion, fine-grained phonetic details support a dynamic view of vowel production. And falling diphthongs should be grouped with monophthongs in the account of vowel phonology in Chengdu Mandarin.

Keywords: vowel, monophthong, diphthong, Chengdu Mandarin, southwestern Mandarin.

1. INTRODUCTION

Chengdu is the capital city of Sichuan Province in southwestern China, and the Chengdu dialect is the representative dialect of southwestern Mandarin [1]. The segmental phonology of Chengdu Mandarin resembles that of Standard Chinese or Beijing Mandarin. A major difference lies in that there is no retroflex sibilants in the consonant inventory of Chengdu Mandarin. In this connection, the segmental inventory of Chengdu Mandarin is like a simplified version of Standard Chinese. And previous phonetic researches on Chengdu Mandarin mainly focused on tones and tone sandhi [2, 3, 4].

Various solutions have been proposed for the analysis of syllable structure for Standard Chinese or Beijing Mandarin [5, 6, 7, 8, 9, 10, 11, 12]. And the major issues are general to all dialects in the Mandarin dialect family. Scholars disagree regarding the number of vowel phonemes. There are basically two different approaches. The first approach is to take vowel elements as is transcribed. In a Mandarin syllable CGVCo, a glide and a vowel GV form a rising diphthong, a vowel and a vocalic coda VCo form a falling diphthong, and the three components GVCo form a triphthong. It is not a difficult task to account for vowel contrasts from a structural distributional analysis of GVCo sequences in Mandarin dialects. Therefore, a five-vowel proposal is favoured in the literature: in addition to the three high vowels [i y u], there are a mid-vowel [e/o/ə/ɤ] and a low vowel [a] [7, 8, 11, 12, 13, 14].

The second approach considers the nature of diphthongs. The unit of vowel could be dynamic and a dynamic vowel phoneme is composed of more than one element. For instance, [10] considered falling diphthongs in Standard Chinese as one phoneme; and [15] even included all monophthongs, diphthongs and triphthongs in the vowel inventory of Standard Chinese.

However, previous studies are mostly phonological analyses focusing on Standard Chinese or Beijing Mandarin. This paper examines vowel production in Chengdu Mandarin, and aims to provide acoustic phonetic details for the analysis of Mandarin vowel phonology. As shown in Table 1, Chengdu Mandarin has 8 monophthongs [ɿ i u y a e o ɚ], 4 falling diphthongs [ai au ei ou] and 6 rising diphthongs [ia ie io ua ue ye]. The rhoticized vowel [ɚ] only appears in open syllables. Due to the space limit, discussion is focused on monophthongs and diphthongs in open syllables.

vowels	(C)(G)V	(C)(G)VN
Monophthongs	ɿ i u y a e o ɚ	ã ən in yn aŋ oŋ
Rising diphthongs	ia ie io ua ue ye	iã uã yã uən iaŋ uaŋ yoŋ
Falling diphthongs	ai au ei ou	
Triphthongs	uai uei iau iou	

Table 1: Vowel inventory of Chengdu Mandarin.

2. METHODOLOGY

10 native adult speakers, 5 male and 5 female, provided the speech data during a fieldwork in 2015. All speakers are born and raised up in Chengdu and have no reported speech and hearing disorders.

Meaningful monosyllabic words were used as test words. Each test word contains a target vowel with an initial of labial stop. Each test word was placed in a carrier sentence [X, tu X san pian] (X, read X three times). 5 repetitions were recorded.

The 16-bit audio sound was recorded directly into a laptop PC through a TerraTec DMX 6Fire USB sound card with a SHURE SM86 microphone. The sample rate is 11,025 Hz.

The annotation work is done in Praat 6.0.40 [16]. Diphthongs were annotated as being composed of three segments, namely an onset, a transition and an offset. The lowest four formants were extracted in the midpoint of each target element and the duration of each segment was also measured.

3. RESULTS

3.1 Monophthongs

Figure 1 shows the distribution of the 8 Chengdu monophthongs [ɿ i u y a e o ɚ] for male (upper) and female (lower) speakers respectively in a two-dimensional acoustic plane (F1 against F2) with the origin of the axes to the top right of the plot. The ordinates are bark scaled, but the values along the axes are still labelled in Hz. Each 2-sigma ellipse is based on 50 data points (5 repetitions × 5 speakers × 2 test syllables).

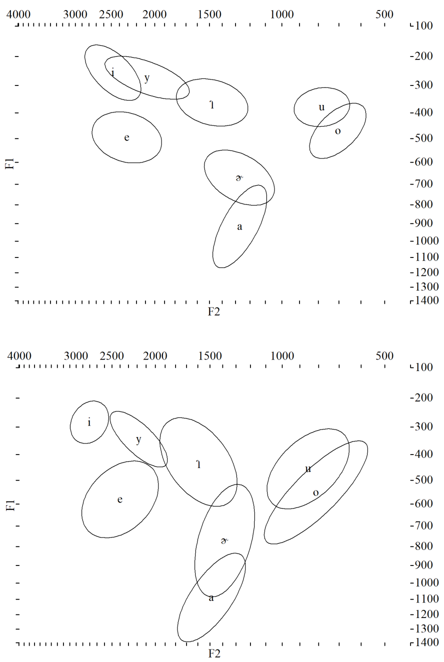

Figure 1: 2-sigma ellipses for the Chengdu monophthongs in males (upper) and females (lower).

The 8 monophthongs of Chengdu have a triangular distribution in the acoustic vowel space. There is a 3-way vowel height, a 2-way backness, and a 2-way lip rounding. [ɿ i y u] are high vowels, [e o] are mid vowels, and [a] is low; [i y e] are front, and [u o] are back; [ɿ i e a] are unrounded, and [y u o] are rounded. However, only front high vowels distinguish in lip rounding, and all back vowels are rounded by default. In addition to the major vowel features, [ɚ] contrasts with other vowels in rhoticity.

It should be noted that the ellipses for the two back vowels [u o] overlap with each other. This is a characteristic that is also attested in other southwestern Mandarin dialects such as Longchang [17] and Changde [18], but is not common for other dialects such as Hangzhou Wu [19] or Xupu Xiang [20]. This is probably due to the fact that in southwestern Mandarin, [u] is usually pronounced as an approximant [ʋ] or sometimes even featured with a slight friction.

3.2 Diphthongs

3.2.1. Temporal structure

Figure 2: Temporal structure in millisecond of diphthongs in males (upper) and females (lower).

Figure 2 and 3 show the temporal structures in millisecond and in percentage of Chengdu diphthongs respectively. There is an apparent difference between the two types of diphthongs. The onset is the dominating component in falling diphthongs while the offset is the dominating one in rising diphthongs. Mandarin falling diphthongs are known for their smooth gliding transitions. That is, the transition plays an important role, which is demonstrated by a long duration in the figure. This is quite different from the dialects such as Taiyuan Jin [21] whose falling diphthongs have abrupt gliding transitions with a short duration.

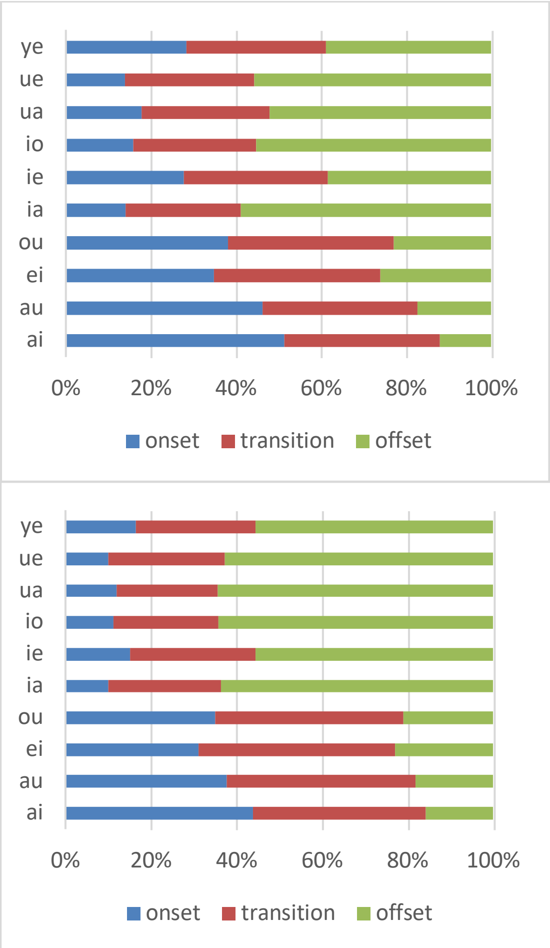

Figure 3: Temporal structure in percentage of diphthongs in males (upper) and females (lower).

3.2.2 Spectral properties

Figures 4 and 5 compare 2-sigma ellipses of the onset and offset elements in falling diphthongs and their monophthongal counterparts in acoustic F1/F2 vowel planes. A diphthong element is denoted by the other element in parenthesis.

The onsets in [ai au] exhibit comparable variability with the corresponding monophthongs, and their ellipse extensively overlap with each. In contrast, the offsets in [ai au] are distributed apparently different to their monophthongal counterparts, and exhibit more variability. That is, only the onsets in [ai au] have comparable spectral targets as do their monophthongal counterparts, but the offsets do not.

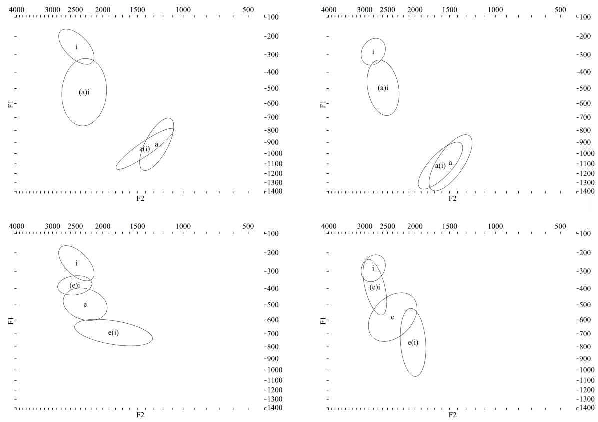

Figure 4: 2-sigma ellipses for the onset and offset of [ai ei] and corresponding monophthongs in males (left) and females (right).

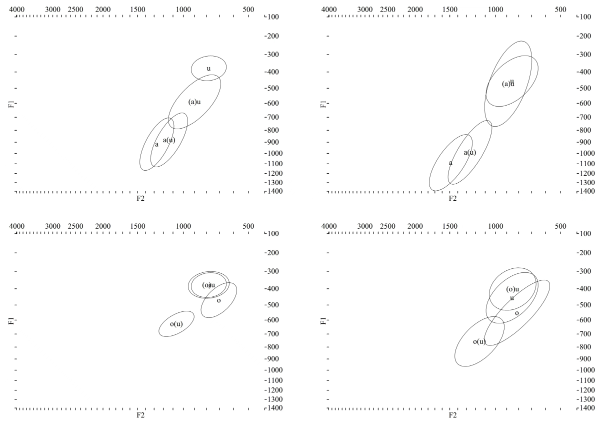

Figure 5: 2-sigma ellipses for the onset and offset of [au ou] and corresponding monophthongs in males (left) and females (right).

The other two falling diphthongs [ei ou] demonstrate a totally different pattern. The production of [ei ou] begins from a lower region and ends at a higher region than the corresponding onset monophthong [e o] respectively. A comparison between diphthong elements and their monophthongal counterparts is not a viable way to evaluate the formant data, since the ellipses for the onsets in both diphthongs [ei ou] and the offset in [ou] have spectral distributions apparently different to their monophthongal counterparts but the ellipses for the offset in [ou] and the monophthong [u] happen to overlap extensively. What is crucial here is that [ei ou] are dynamic high vowels, which contrast with dynamic low vowels [ai au] respectively on the one hand, and contrast with static mid-high vowels [e o] on the other hand. In summary, it is not justifiable to treat falling diphthongs as sequences of vowels, as not all diphthong elements have comparable spectral distribution as do their monophthongal counterparts. Rather, falling diphthongs should be treated as dynamic vowels. Therefore, accepting the dynamicity as a vowel feature help understand distinctive relations of vowel phonology in Chengdu Mandarin as well as in other Chinese dialects in general.

Figures 6 to 8 compare 2-sigma ellipses of the onset and offset elements in rising diphthongs and their monophthongal counterparts in the acoustic F1/F2 vowel plane.

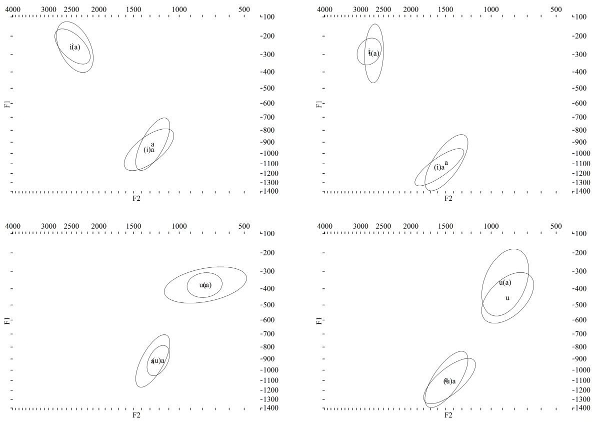

Figure 6: 2-sigma ellipses for the onset and offset of [ia ua] and corresponding monophthongs in males (left) and females (right).

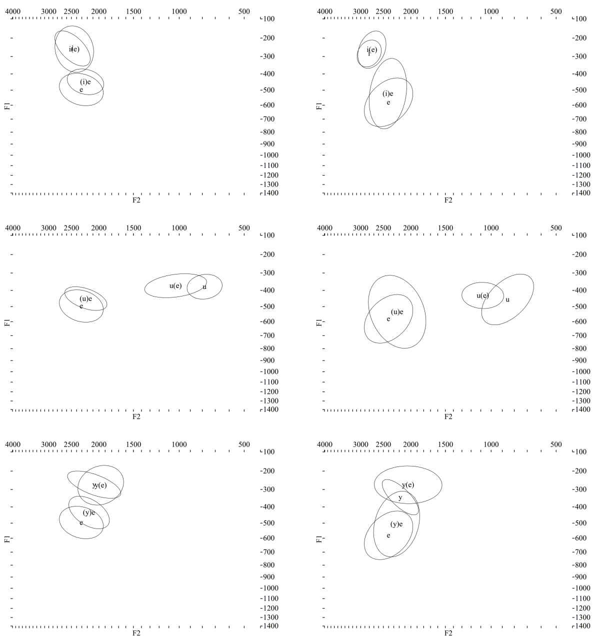

Figure 7: 2-sigma ellipses for the onset and offset of [ie ue ye] and corresponding monophthongs in males (left) and females (right).

Unlike in falling diphthongs, both onset and offset elements in rising diphthong have spectral distributions comparable to their monophthongal counterparts, since their ellipses overlap with each other and exhibit comparable variabilities in general. Therefore, rising diphthongs could be treated as sequences of vowels, since both onsets and offsets have comparable spectral targets as do the corresponding monophthongs. There are surely certain degree of coarticulatory effect on diphthong elements. For instance, it seems that the onset of [io] demonstrates an apparent effect of coarticulation, and its distribution is shifted to a spectral region posterior to the monophthong [i].

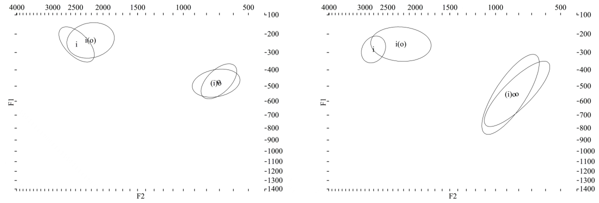

Figure 8: 2-sigma ellipses for the onset and offset of [io] and corresponding monophthongs in males (left) and females (right).

In summary, formant data suggest a typological difference between falling diphthongs and rising diphthongs in Chengdu Mandarin. Rising diphthongs are sequences of vowels whereas falling diphthongs should better be understood as a dynamic unit of vowel.

4. CONCLUSION

This paper gives an acoustic phonetic analysis of the monophthongs and diphthongs in Chengdu Mandarin. Both durational data and spectral data reveal a typological difference between falling diphthongs and rising diphthongs. Fine grained phonetic details support a dynamic view of vowel production [22, 23]. Rising diphthongs are vowel sequences, as both onset and offset elements have spectral targets comparable to the corresponding monophthongs. Falling diphthongs are dynamic units of vowels. The production of falling diphthongs are characterized by the feature of dynamicity rather than an onset target and an offset target, since not all onset and offset elements have spectral targets comparable to their monophthongal counterparts in Chengdu Mandarin.

Therefore, both monophthongs and falling diphthongs should be taken into account for vowel phonology of Chengdu Mandarin. For instance, in addition to the three static levels of distinction in vowel height, there are two more dynamic levels of height distinction. That is, Chengdu Mandarin has a 5-way distinction of vowel height, namely [i u] are static high vowels, [e o] are static mid vowels, [a] is the static low vowel, [ei ou] are dynamic high vowels, and [ai au] are dynamic low vowels.

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