VOWEL SYSJEMS IN MANDARIN LANGUAGES

by

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Vowel Systems in Mandarin Languages

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Abstract

This dissertation presents a comparative study of the vowel systems in 37 Mandarin languages.

I examine the phonological vowel inventory in each language based on evidence from the distribution of the surface vowels. The distribution includes where a surface vowel is found, and how it relates to other segments in the language. One striking fact which is found in all the Mandarin languages examined is that the vowel /ə/ is always able to assimilate to a neighboring glide [j], and in some languages to both [j] and [w]. Some constraints are called for in order to explain the full range of data in Mandarin. These constraints include the domain, locality, and structure in /ə/ assimilation, the degree of structural complexity of certain segments, the requirement of the Obligatory Contour Principle, the structure for the application of certain default rule, and the type of vowel sequences that are allowed. These are the fabric of Mandarin vowels.

The study is conducted within the framework of the contrastive specification approach developed at the University of Toronto. This theory suggests that a vowel is specified for a feature either because of its phonological behavior in the language, or because of its contrast with other vowels in the language. Four types of Mandarin phonological vowel inventories have been identified depending on the number of phonemes in each system and

the way each phoneme is realized on the surface. The results of feature specification in each language account for the phonology in the language. For instance, in the language Chengde, there are two vowels specified for a place feature. Both vowels are triggers of place assimilation in the language. In the language Harbin, only one vowel is specified for place feature. This is also the only vowel that acts as a trigger in place assimilation in the language. In a different approach, say full specification, where a vowel is fully specified, there would be no explanation for the fact that both vowels acting as the trigger of place assimilation in one language whereas only one in the other.

Mandarin phonological vowel inventories provide insight into the issue of vowel place feature markedness. In particular, in the Harbin-type languages, the place feature [Coronal] is present in the vowel system; the place feature [Labial] is absent. [Labial] is less marked than [Coronal] at least in these languages.

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Chapter 1 Introduction

This thesis is a comparative study of vowel systems in Mandarin languages. There are two goals of the thesis. The first is to conduct a detailed study of the sound patterns of selected Mandarin languages, focusing on vowel inventories. Such a comparative study of different Mandarin vowel systems has not been done before. The second goal of the thesis is to examine Mandarin vowel inventories within the theory of contrastive specification, showing that the vowel realized as [u] is variable in its patterning across the family.

In this chapter I introduce in section 1.1 the group of Mandarin languages to be examined in the thesis. In section 1.2 I present the outline of the thesis.

1.1 Mandarin languages under study

In this section I introduce the Mandarin languages. First a few comments on definitions. The term "Chinese" (language) has been used in both broad and narrow senses. Linguistically speaking, "Chinese languages" refers to the seven language families spoken within China. They are: Wu, Xiang, Gan, Hakka, Min, Yue, and Mandarin.

Mandarin is the largest family among the seven, in terms of both area and population. Mandarin can be further divided into five linguistic sub-groups: the northern, the northwestern, the Jin, the southwestern, and the Jianghuai groups.[1] When I introduce each of the Mandarin languages under study in the thesis, I will mention the sub-group each belongs to. The geography of the four subgroups will be seen then.

[1] This classification is based on Chen and Li 1996. Jin was not treated as an independent subgroup in Yuan 1960. Recently it has been proposed that Jin is a language family by itself, parallel to Mandarin and other Chinese language families (personal communication with Jenny Wang).

Most of the data of the languages included in this study come from Chen and Li 1996, a book of five volumes, with data on 93 Mandarin languages. The data include the consonant and vowel systems and consonant-vowel cooccurrence sequences in each language (volumes 1 and 2), and the pronunciation in the 93 languages of close to 3,000 lexical items (volumes 3, 4, and 5). My comparative study of the Mandarin vowel systems would be impossible without this book.

The Mandarin languages to be examined in this thesis are divided into two major groups according to the size of the vowel inventory, i.e., four or five-vowel inventories. Four-vowel inventories are discussed in Chapter 4. Five-vowel inventories are discussed in Chapter 3. Four-vowel inventories can be further divided into two types according to the inventory shape. The first type includes 12 languages with four-vowel inventories. Some relevant data is provided in the table below.

(1) Mandarin languages with four-vowel inventories: type I

Languages	Mandarin sub-group	Province	Population
Harbin √	Northern	Heilongjiang	2,520,000
Qiqihar	Northern	Heilongjiang	1,210,000
Heihe	Northern	Heilongjiang	70,000
Jiamusi	Northern	Heilongjiang	3,000,000
Baicheng	Northern	Jilin	2,610,000
Changchun	Northern	Jilin	1,750,000
Tonghua	Northern	Jilin	360,000
Shenyang	Northern	Liaoning	5,200,000
Dalian	Northern	Liaoning	1,480,000
Chifeng	Northern	Inner Mongolia	290,000
Linhe	Jin	Inner Mongolia	370,000
Taiyuan	Jin	Shanxi	1,750,000

In the above table, I list the Mandarin sub-group each language belongs to, the province each city is located in, and the population of each city. As we see, most languages in this type belong to the northern sub-group, though some belong to the Jin sub-group. The population of each location/city is given. I choose the language Harbin for a case study in Chapter 4. See Appendix 3 for the geographical location of each language.

The second group includes 19 languages with another type of four-vowel inventory. I provide below relevant information in (2).

(2) Mandarin languages with four-vowel inventories: type II

	Mandarin sub-group	Province	Population
Chengde √	Northern	Hebei	330,000
Tangshan	Northern	Hebei	1,410,000
Baoding	Northern	Hebei	500,000
Cangzhou	Northern	Hebei	4,000,000
Shijiazhuang	Northern	Hebei	1,070,000
Dandong	Northern	Liaoning	550,000
Hailar	Northern	Inner Mongolia	160,000
Lingbao	Northern	Henan	580,000
Yuanyang	Northern	Henan	490,000
Beijing	Northern	Beijing	9,180,000
Tianjin	Northern	Tianjin	7,790,000
Yantai	Northern	Shandong	390,000
Jinzhou	Jin	Shanxi	390,000
Yangyuan	Jin	Hebei	230,000
Handan	Jin	Hebei	930,000
Tianshui	North-western	Gansu	190,000
Hanzhong	North-western	Shanxi	370,000
Hami	North-western	Xinjiang	430,000
Urumchi	North-western	Xinjiang	960,000

The languages in (2) belong to three different Mandarin sub-groups, northern, northwestern, and Jin, and to ten different provinces. Chengde is chosen as the representative language for discussion in Chapter 4. See Appendix 3 for the geographical location of each language.

The third type of Mandarin languages has a five-vowel inventory. These languages include Linfen, Jining, Xiangfan, and Yichang, as shown below.

(3) Mandarin languages with five-vowel inventories: type I

	Mandarin sub-group	Province	Population
Linfen √	Northern	Shanxi	210,000
Jining	Northern	Shandong	740,000
Xiangfan	Southwestern	Hubei	320,000
Yichang	Southwestern	Hubei	370,000

A case study of Linfen is presented in Chapter 3. See Appendix 3 for the geographical location of each language.

The fourth and last type of Mandarin languages under study includes another set of five-vowel inventories. These languages include Wuhan and Tianmen. Some relevant figures are given below.

(4) Mandarin languages with five-vowel inventories: type II

	Mandarin sub-group	Province	Population
Wuhan √	Southwestern	Hubei	3,290,000
Tianmen	Southwestern	Hubei	1,360,000

Wuhan is studied in Chapter 3. See Appendix 3 for the geographical location of each language.

1.2 Outline of the thesis

In Chapter 2 I lay out the general theoretical framework I follow in the thesis. I adopt the contrastive specification approach (Avery and Rice 1989, Dyck 1992, 1995, Rice 1992, 1993a,b, 1994, Rice and Avery 1993, Wilson 1993, Rose 1993, Walker 1993, Dresher 1994, Dresher, Piggott and Rice 1994, Wu 1994, Zhang 1996, among others) for analyzing phonological vowel inventories. I also adopt the feature geometry approach (Clements 1985, 1991, Sagey 1986, van der Hulst 1989, Rice and Avery 1991, Odden 1991, Lahiri and Evers 1991, Goad 1991, Clements and Hume 1995, among others) as a tool to structurally represent specified features and phonological processes such as place assimilation. In Chapter 2 I also discuss some assumptions about Mandarin languages, which are required for the discussion in Chapters 3 and 4. These include assumptions about Chinese syllable structure, Mandarin consonant systems, and the status of surface palatal consonants in Mandarin.

Chapters 3 and 4 are the language chapters. Four types of Mandarin languages are examined, based on the vowel inventories. Chapter 3 includes two types of five-vowel inventories and Chapter 4 includes two types of four-vowel inventories. In both chapters I focus on the relationship between phonetic and phonological vowel inventories, i.e., how a phonetic inventory is derived from a phonological inventory.

In Chapter 5 I address the implications of Mandarin vowel inventories for two theoretical issues, the procedure of feature specification and markedness relations in vowel inventories.

In Chapter 6, I summarize the major contributions of the thesis.

Chapter 2 Theoretical framework and assumptions

In this chapter I lay out the theoretical framework I follow for the present study as well as some assumptions about Mandarin languages that are crucial to the examination of Mandarin vowel systems. There are five issues I will address and the chapter is organized accordingly. The first two issues relate to the theoretical framework. In section 2.1.1 I discuss the idea of contrastive specification. In section 2.1.2 I discuss the structural representations I use for specified features, i.e., feature geometry. The other three issues relate to assumptions about Mandarin languages. In section 2.2.1 I address Mandarin syllable structure. In section 2.2.2 I discuss the patterns of consonant systems of Mandarin languages, in particular the place feature specifications of consonants. Lastly in section 2.2.3 I consider the status of surface palatal consonants in Mandarin languages. Section 2.3 concludes the chapter.

2.1 Theoretical framework

2.1.1 Contrastive specification

This study results from the Contrast and Complexity in Phonology project which I have been working on for three years at the University of Toronto (Avery and Rice 1989, Rice 1992, 1993a,b, 1994, Rice and Avery 1993, Wilson 1993, Rose 1993, Walker 1993, Dresher 1994, Dresher, Piggott and Rice 1994, Wu 1994, Dyck 1992, 1995, Zhang 1996, Avery 1996, Hamilton 1996, among others). In this section, I present the contrastive specification approach, a major theme of the project, which I pursue in the study.

Before I lay out the general principles, I illustrate the framework with two cases.

The first language is Afar, a Cushitic language. In this language there are two high vowels, front [i] and back [u]. The vowel [i] assimilates to [u], but not the other way round. The second language is Korean (both Afar and Korean from Rose 1993). In this language there are three high vowels, front [i], back [u], and central [ɨ]. Here the central vowel [ɨ] assimilates to front [i] and to back [u]. In both cases we see an asymmetry in assimilation.

This asymmetrical pattern in assimilation can be explained if we assume that vowels are not defined by all features they have phonetically, but by the number of vowels in the system. In a language like Afar, where there are two high vowels, one feature is sufficient to distinguish one from the other. Let us assume that this feature is Labial; see section 2.1.2. The vowel /u/ is given this feature. The vowel /i/ is not given this feature, meaning it is not Labial, as shown in (1).

(1) Afar high vowels

/i/	/u/
	[Labial]

Assuming that triggers are characterized as having features to give, while targets can receive features, the fact that /i/ assimilates to /u/ can be explained. It takes on from /u/ a feature which it does not have.

In the second language, Korean, there are three high vowels. Two features are sufficient in order to distinguish one from the other. Let us assume that one feature is Labial, given to /u/, and the other feature is Coronal, given to /i/. /ɨ/ is left without a feature. I show this in (2).

(2) Korean high vowels

[i]	[u]	[ɨ]
[Coronal]	[Labial]	

This time since /ɨ/ does not have any feature, it is eligible to take on features from /i/ and from /u/.

Comparing the two languages, the vowel /i/ deserves comment. This same vowel is defined differently in the two languages, since the inventory shapes are different in the two languages. The vowel /i/ does not have a feature phonologically in Afar but has one in Korean. This difference in underlying representation predicts nicely that /i/ acts as a target in Afar (without a feature), but as a trigger in Korean (with a feature). This representational approach allows for systematic differences in patterning that are related to systematic differences between inventories to be accounted for in a straightforward and non-stipulative way.

Above I have shown with two language cases the motivation of the contrastive specification approach I pursue in the study. One might ask the following questions regarding the above example. How do we determine how many features are needed for a two-high-vowel system and how many features are needed for a three-high-vowel system? How do we decide to give the feature Labial to /u/ in Afar, but to give the features Coronal and Labial to /i/ and /u/, respectively, in Korean?

In accordance with ideas developed in works such as Avery and Rice 1989, Rice 1992, 1993a,b, 1994, Rice and Avery 1993, Dyck 1992, 1995, Wilson 1993, Rose 1993, Walker 1993, Dresher 1994, Dresher, Piggott and Rice 1994, Wu 1994, and Zhang 1996, among others, I assume that the features required to characterize a segment, vowel or consonant, are determined by the following two factors: (1) the number of contrasts in the system; (2) the phonology of the language. I explain these two principles next.

First, how many feature(s) a segment carries depends on the number of contrasts in the system. I take high vowels as examples for illustration. If there is only one high vowel in a system, this vowel does not contrast with another segment at its height. In other words, the vowel does not contrast in place (front vs. central vs. back) with another segment. In this case no place feature needs to be specified on this vowel. However, if there are two high vowels in a system, say a front one /i/ and a back one /u/, one place feature is required to distinguish between the two. That is, either a front place feature (assuming [Coronal]) could be specified on /i/, or a back place feature (assuming [Labial]) could be specified on /u/, but not both. Further, in a third situation, if we add one more high vowel, we have a front one /i/, a central one /ɨ/, and a back one /u/. Now two place features are needed to distinguish between the three. Assuming that central place does not involve a place feature (e.g., Clements 1991, Rose 1993, Walker 1993, Steriade 1995, and Rice 1995), the front /i/ is specified with the place feature Coronal and the back /u/ is specified with the place feature Labial.

Thus specification is a relative issue. The status of a segment in a system is relative to other segments in the system. If the system involves fewer contrasts, fewer features are required for the purpose of specification. On the other hand, if a system involves more segments, more features are required for contrasts.

The second factor that determines feature specifications is patterning within the language. I continue with high vowels as examples. Above I have mentioned a situation in which there are two high vowels in the system, /i/ and /u/. Only one place feature is needed in order to distinguish between the two. The question is: how is that feature determined? I claim that it is necessary to turn to phonological patterning to see which member of the pair is actually selected for specification. Below I give a few hypothetical situations.

First, if, in a language, the vowel /u/ is found to trigger round harmony whereas the vowel /i/ is not found to participate in any phonological activities, we may conclude that /u/ should be specified with a place feature Labial since this feature is active in the phonology. /i/, on the other hand, does not need to be specified for place underlyingly since its place feature is inert in the language. In this case vowel harmony helps to determine specification.

Second, if, in a language, the front vowel /i/ triggers fronting of schwa, whereas the back vowel /u/ does not trigger backing of schwa, this suggests that /i/ should be specified with a place feature since this feature is active in the phonology. /u/ is not specified with a place feature since this feature is inert in the language. In this second case, assimilation patterning helps to determine specification.

In a third situation, if in a language the vowel /i/ is the vowel that is deleted in a certain environment while /u/ remains, this might provide evidence that /i/ is a less marked vowel than /u/ and so is left unspecified for the place feature.[2] In this case the phonological process of deletion helps to determine specification. See Rose 1993 for discussion of relevant languages.

Above I have discussed two factors that determine the feature specifications of segments. Next I use a simple [i, u, a] three-vowel inventory to show how these two factors work together.

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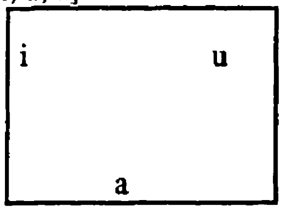
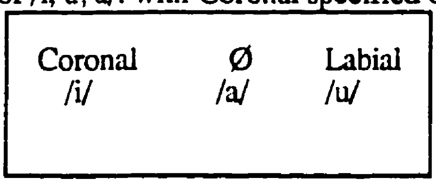
[2] I use the term "might" here since deletion of a segment can also be caused by other factors, for instance, the position of a segment.

(3) Phonetic vowel inventory of [i, u, a]



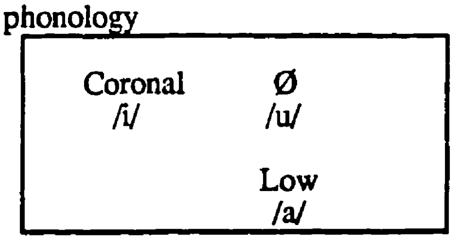
Suppose, as above, that in a language both of the two phonetic high vowels [i] and [u] are found to be active phonologically, triggering fronting and rounding respectively. Thus both vowels need to be specified with place features. The vowel [i] is specified with Coronal, and [u] with [Labial]. The third vowel [a] is left unspecified for any feature since the three vowels have already been contrasted from each other. Notice all three vowels are unspecified for height feature, which means they can be regarded as at the same phonological height. I show the resulting phonological system in (4). Note that place is illustrated on the horizontal axis; height will be marked on the vertical axis (see (5), for instance).

(4) Phonological inventory of /i, u, a/: with Coronal specified on /i/ and Labial on /u/



However, the same phonetic three-vowel inventory could differ in terms of phonological behavior. I show a few more possibilities below, each with the results of specification.

(5) Only Coronal active in phonology



In this case only the vowel /i/ is active in the phonology, say, by triggering fronting. The vowel /u/ is inert. Thus /i/ is specified with a place feature Coronal. The other two vowels /a/ and /u/ can be further distinguished by a height feature, say, Low on /a/.[3]

(6) Only Labial active in phonology

Ø /i/	Labial /u/
Low /a/	

This is a mirror image of the case in (5). In this language only the vowel /u/ is active in the phonology, say, by triggering rounding harmony. The vowel /i/ is inert. Thus /u/ is specified with a place feature Labial. The other two vowels /a/ and /i/ can be further distinguished by a height feature, again, say, Low on /a/.

In showing the above different scenarios, I have made the following claim regarding the ordering of the two basic factors that determine feature specifications of a system (see also Dresher 1998). That is, first, look for phonological patterning, if any, in the language, and decide which feature should be assigned. Then, if necessary, look at contrasts in the system, and decide what other features are further needed. As we see, in (4), both place features Coronal and Labial are selected because both are active. No height feature is necessary in this case. In (5), the place feature Coronal is chosen because it is active. The height feature Low is selected to further distinguish the rest of the segments in the system. If Labial had been selected here, there would be no explanation for the asymmetry in the patterning of place features. In (6), the place feature Labial is chosen because it is active.

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[3]We might find some patterning of Low in the phonology. The result of specification would be the same.

Further, as in (5), the height feature Low is chosen to further distinguish the other segments in the system.[4]

In Chapter 4, I will show that in Mandarin languages such as Harbin only the front vowel (written as /E/) triggers place assimilation, while in other Mandarin languages such as Chengde, both the front vowel and the back vowel (written as /E/ and /O/ respectively) trigger place assimilation. These patterns are captured by the contrastive specification approach as presented above. That is, in Harbin, only the front vowel is specified with a place feature. Thus only the front vowel acts as a trigger of place assimilation. In Chengde, both the front and the back vowels are specified with a place feature. Thus both vowels act as a trigger of place assimilation. These patterns would be difficult to explain under a different approach, say, full specification, in which case the assimilation rules would have to refer to specific place features (Coronal only in Harbin and Coronal and Labial in Chengde) and so is stipulative.

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[4]There is one more possibility which I do not exclude.

Coronal /i/		Labial /u/
	Low /a/	

Suppose in this system all three vowels /i/, /u/, and /a/ are found to be active in the phonology. For instance, /i/ triggers front assimilation; /u/ triggers rounding assimilation; /a/ triggers Low harmony. Thus all three vowels are specified with a feature: Coronal on /i/, Labial on /u/, and Low on /a/. In this case the number of phonological patterns (3) is larger than the number of features required (2) to contrast the three vowels. In other words, the minimal number of contrasts (of features) could be violated, but only when there is a larger number of phonological patterns in the language. This possibility, however, is not found in the Mandarin languages under study.

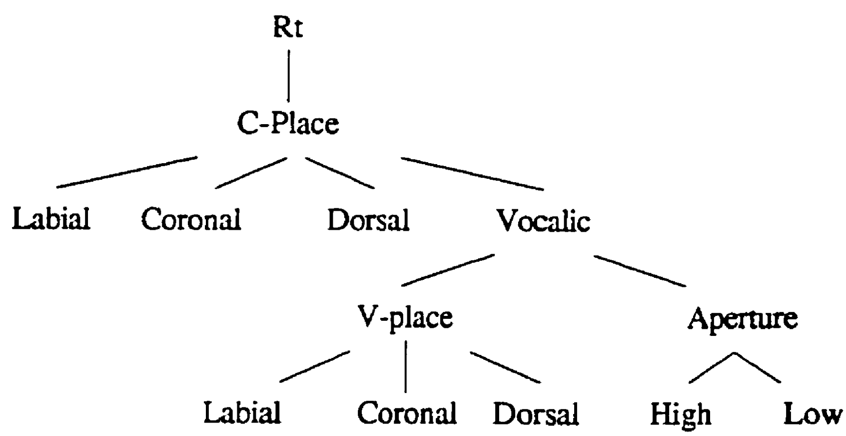
Notice that in the above discussion I have talked about selecting one feature before another, with the selection of one feature limiting further possible choices (also see Dresher 1998). I will use the word "ordering" in discussing this notion. Thus, in (4), the place features are selected, or ordered first, while in (5), the place feature Coronal is selected followed by the height feature Low. I will say that place is ordered before height in (4), and vice versa in (5). It has been raised as a hypothesis of the Contrast and Complexity project whether there is a fixed ordering of features that determines the domain of specification (see Walker 1993, Dyck 1995, Zhang 1996, Dresher 1998, among others). For instance, Walker 1993 suggests an ordering of height features prior to place features, and within height features Low prior to High, within place features Labial prior to Coronal. Zhang 1996, based on evidence from Manchu-Tungus languages, argues that an alternative ordering of place features is possible, with Coronal chosen before Labial. It is one of the major goals of the thesis to show that a fixed hierarchy cannot meet the needs of different languages. Rather the specific phonology of the specific language determines the ordering of features in the specification procedure. I will explore this idea in more detail in section 5.1 of Chapter 5.

There is one more issue that I would like to raise here regarding the contrastive specification approach. As we see, under this approach, only some phonetic features are present in phonology, either because these features are active in the language or because they serve to make contrasts in the system. Thus an important question is the following: how does a partially specified segment surface? I assume that the features not represented in the phonology are spelled out on the surface by universal default rules, i.e., rules that apply to languages in general under normal conditions. For instance, in (4), front and back vowels are specified for place, and no vowels are marked phonologically for height. Yet phonetically these features are required. I discuss the details of the default rules in Chapters 3 and 4.

2.1.2 Feature geometry: structural representations of feature specifications

I assume feature geometry for place and height as a way to structurally represent feature specifications. Following the feature geometry found in works such as Clements 1985, Sagey 1986, van der Hulst 1989, Clements 1991, Rice and Avery 1991, Odden 1991, Lahiri and Evers 1991, Goad 1991, and Clements and Hume 1995, among others, I assume the following feature geometry tree:

(7) Assumed feature geometry (place and vowel height)



The tree above represents place features of both consonants and vowels and height features of vowels. Vowel features include place features, which are under the V-place node, and height features, which are under the Aperture node. Further, I assume Labial (for round), Coronal (for front), and Dorsal (for back) for vowel place features, and High and Low for vowel height features. I point out here that the place feature Dorsal is used minimally in the study; it does not appear in the underlying representations of the vowels. This is because I assume that all the back (Dorsal) vowels in the languages under study are phonologically round (Labial). I thus use Labial, not Dorsal, as the underlying place feature (if necessary at all) of these back vowels. For consonant features, for the purpose of the thesis, I focus on place features, ignoring aspects such as manner and voicing. Notice that vowels and consonants have the same set of place features (e.g., Clements 1991, Clements and Hume

1995). I also assume that all features are privative (Avery and Rice 1989, Rice and Avery 1991, Steriade 1995, among others).

There is one specific comment on place features of central vowels such as /ɨ/, /ə/, and /a/. I assume that central vowels such as /ɨ/, /ə/, and /a/ are unspecified for place features, and thus have no articulator node and so are not specified with any place feature (e.g., Clements 1991, Rose 1993, Walker 1993, Steriade 1995, and Rice 1995).

2.2 Assumptions about Mandarin languages

There are some basic assumptions about Mandarin languages in general which directly relate to the study of vowel systems in these languages. These assumptions include: Mandarin syllable structure, patterns of consonant systems in Mandarin languages, and the status of surface palatal consonants. I discuss these next.

2.2.1 Mandarin syllable structure

In Mandarin languages, the status of a vowel often depends on the syllable position it appears in. For instance, what I will call high vowels have a dual syllabic status, occurring as a vowel when syllabified in a nucleus and as a glide when syllabified in an onset or coda. Thus, discussion of vowels requires reference to syllable positions. In this section I give my assumptions about syllabification in Mandarin languages in general.

I assume the following general syllabification process, which can be found in works such as Steriade 1982, and Levin 1985, among others:

(8) Syllabification process

(a) The most sonorous segment projects the nucleus;

(b) Segments preceding the nucleus go in the onset;

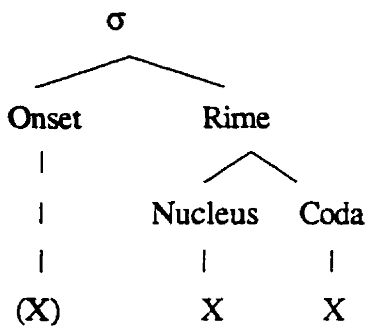
(c) Segments following the nucleus go in the coda;

(d) The nucleus and the coda form the rime; the rime and the onset form the syllable.

There are two points I want to address here. First is step (a): how is the most sonorous segment determined? It is generally assumed that vowels are more sonorous than consonants (see, for instance, Kenstowicz 1994: 254-255). Among vowels, it has been suggested that low vowels are more sonorous than non-low vowels, and mid vowels are more sonorous than high vowels (e.g., Selkirk's 1984 sonority index, Wu 1994). This yields the following sonority hierarchy: low vowels>mid vowels>high vowels>consonants (> more sonorous). There are two further questions which are related to my study. First, what happens when there are two vowels at the same height, say two mid vowels /e/ and /ə/? Following Wu 1994 on Beijing Mandarin, I assume that a segment specified with a place feature is less sonorous than a segment unspecified for a place feature. Thus /ə/ is considered more sonorous than /e/. Given a sequence /eə/, then, the schwa will form the nucleus, and /e/ must go in a non-nuclear position. Second, what happens when two vowels at the same height, say /e/ and /o/, are both specified with a place feature? The evidence in the Mandarin languages to be examined in Chapter 3 suggests that the round vowel is more sonorous and thus goes in the nucleus.

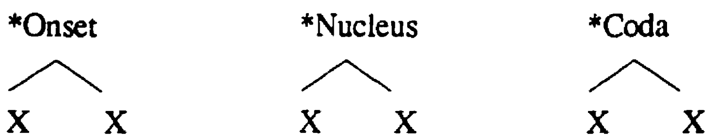
The second point I want to address is: what does the syllable structure deriving from steps (a-d) look like in Mandarin languages? In other words, what are the specific structural requirements for Onset, Nucleus, and Coda in these languages? Duanmu 1990 examined the "initial" and "final" (roughly corresponding to "onset" and "rime" respectively) inventories of eight Chinese languages coming from eight language families (which cover all Chinese language families; Mandarin is one of the eight families) and proposed a uniform syllable structure for Chinese languages in general, as shown in (9).[5]

(9) Mandarin syllable structure (brackets indicating optionality)



The structure in (9) requires that there is only one (and no more than one) timing slot (X) for each of the three positions, Onset, Nucleus, Coda. That is, none of them can have a branching structure, as shown in (10).

(10) Non-branching onset, nucleus, and coda



Suppose now that a morpheme contains a string with two vowels where the first one is high, Duanmu proposed that the high vowel shares the slot with the onset consonant and serves as secondary articulation on the consonant,[6] as expressed below.

---

[5] I call this structure the Mandarin syllable structure for the purposes of the thesis.

[6] There are different views with respect to this. Fu 1989 and Bao 1990 propose that the onset can branch in some Chinese languages. Wu 1994 brings evidence from /r/ suffixation in Mandarin to support Duanmu. I follow Duanmu in this study. The interested reader is referred to these works for arguments.

(11) Onset consonant with secondary articulation in Mandarin

Onset
|
C^G

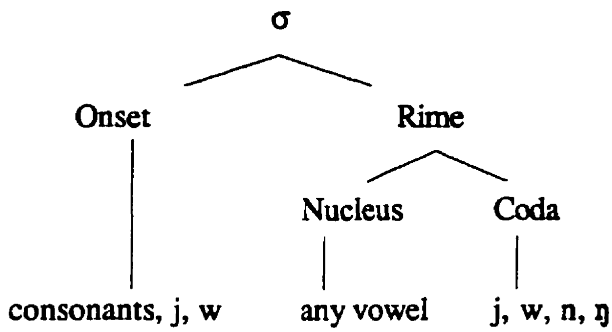
As shown in (9), the onset is optional. In other words, onsetless syllables are allowed in Chinese.

Finally, consider the structure of the rime. Notice that both a nucleus and a coda are required: the syllable is obligatorily bimoraic.

Two further comments are required on the Mandarin syllable template in (9). First, this structure with an obligatory branching rime is required when the syllable has a regular tone, i.e., Tones 1, 2, 3, and 4 in Mandarin; it is not found with a neutral-tone syllable (where the requirement on branchingness of the rime is relaxed). This point will be illustrated in Chapters 3 and 4 when I discuss the vowel /ə/. Second, (9) is a surface template. The bimoraic requirement of the rime holds only at the surface level, not at the point of syllabification, where the rime may contain only a single element. This point will also be discussed in detail in Chapters 3 and 4.

There is one further question further related to (9): what are the segments that can be syllabified in each syllable position? I present the distribution below.

(12) Segments syllabified in each syllable position in Mandarin



The segments syllabified in the onset can be a consonant or a glide, [j] or [w] (these glides derive from underlying vowels; see Chapter 3). When both a consonant and a glide are present in the onset, the glide forms a secondary articulation on the consonant. Any vowel can be syllabified in the nucleus. The coda can contain a glide, [j] or [w] (derived from a vowel), or a nasal, [n] and/or [ŋ] (inventory depending on the language).

Duanmu argued that the syllable structure in (9) is also supported by diminutive suffixational processes and by cooccurrence restrictions on labials in different Chinese languages. The reader is referred to his work for details. I assume the syllable structure in (9) for the Mandarin languages to be examined in the thesis.

To summarize this section on Mandarin syllable structure, I assume that Mandarin surface syllable structure requires a non-branching onset, nucleus, and coda. While the nucleus and coda are obligatory on the surface, the onset is optional. I have shown the segments that can be syllabified in each position. Further, the rime has to be bimoraic on the surface, but not necessarily on syllabification.

2.2.2 Mandarin consonant systems

Consonants interact with vowels in Mandarin languages. Thus, discussion of vowels requires a discussion of consonants. Consonant systems in Mandarin languages are quite similar, differing only in some minor ways. In this section I introduce the Mandarin consonant systems. In particular, I focus on the place features of the consonants, since only place features are relevant to the discussion of vowels in later chapters.

In Mandarin languages, there are two major types of consonant systems based on the criterion of place. One type involves a five-place system, and the other type a six-place system. I show the difference below.

(13) Five-place vs. six-place consonant systems in Mandarin

Language type	Place of articulation					
Type I	Labial	Alveolar	Dental	Ø	Palatal	Dorsal
Type II	Labial	Alveolar	Dental	Retroflex	Palatal	Dorsal

An examination of the chart in (13) reveals that the two language types differ only in the presence vs. absence of retroflex consonants. In Chapters 3 and 4 I will show that this difference leads directly to the presence vs. absence of the surface vowel [ʅ] in the two types of languages.

Next I discuss the place features of each consonant type. First, I assume that labial consonants are specified with the feature Labial and dorsal consonants are specified with the feature Dorsal, as in (14).

(14) Place features of labial and dorsal consonants

labials	dorsals
Rt	Rt
|	|
C-Place	C-Place
|	|
Labial	Dorsal

The alveolars, dentals, and retroflexes are all coronal consonants. I assume Coronal is the unmarked place feature for consonants (e.g. Kean 1975; Avery & Rice 1989; papers in Paradis & Prunet 1991). However, the three types of coronal consonants need to be contrasted. I assume that while alveolars are plain coronals, dentals and retroflexes have a dependent node (Dental and Retroflex respectively) under Coronal. According to the Node Activation Condition as proposed by Avery and Rice 1989, when a node dependent on Coronal comes into play, the Coronal node has to appear in a plain coronal, even though coronal is the unmarked place feature. I repeat the NAC below:

(15) Node Activation Condition (NAC) (Avery and Rice 1989: 183)

> If a secondary content node is the sole distinguishing feature between two segments, then the primary feature is activated for the segments distinguished. Active nodes must be present in underlying representation.

I show the place feature representations of the three types of coronal consonants below.

(16) Place feature representations of the three types of coronal consonants in Mandarin

alveolars	dentals	retroflexes
Rt	Rt	Rt
|	|	|
C-place	C-place	C-place
|	|	|
Coronal	Coronal	Coronal
	|	|
	Dental	Retroflex

There is one more consonant type to be discussed, i.e., palatals. I propose that surface palatals in Mandarin are underlyingly dorsal consonants realized on the surface with palatalization (see Wu 1994, among others, for a similar proposal). I address this issue next.

2.2.3 Status of surface palatal consonants in Mandarin

One striking phenomenon in Mandarin languages is that palatal consonants are always found in complementary distribution with dorsal consonants. It is this distributional pattern as well as assumptions about syllable markedness that lead me to propose that surface palatals in Mandarin are derived from underlying dorsals in the environment of a front vowel. This proposal has frequently been made in the Chinese literature; see, for instance, Chao 1968, Hsueh 1985, Lin 1989, and Wu 1994 for discussion. I take one Mandarin language, Wuhan, as an example and show this.

The distributional patterns of consonant-vowel sequences of Wuhan are presented in four tables. First a few comments are needed on the tables. Table 1 is a phonetic table which shows the consonants at the different places of articulation (rows) and the rimes that occur with each of these consonants (columns). Tables 2, 3, and 4 differ from Table 1 in that the consonants heading the rows in Table 1 each take on a secondary articulation. That is, the rows are headed by consonants with palatalization in Table 2, by consonants with labialization in Table 3, and by consonants with both palatalization and labialization in Table 4.

There is one point I want to address here about the four tables which is crucial for my arguments of the status of surface palatals. Table 1 consists of CV(G/N) syllables (C=consonant; V=vowel; G=glide; N=nasal). Tables 2 and 3 consist of CGV(G/N) syllables. Table 4 consists of CGGV(G/N) syllables.[7] If we ignore the final (G/N) part which is found in all three syllable types and compare CV, CGV, and CGGV, there exists the following implicational relationship: the existence of CGGV syllables implies the existence of CGV syllables, and the existence of CGV syllables implies the existence of CV syllables (see Blevins 1995: 217 for discussion of such implicational relationships). One can equate implication with markedness (see Trubetzkoy 1939, Greenberg 1966, Steriade 1995, Blevins 1995, and Hamilton 1996, among others). Implicational relationships are often used in the literature for determining markedness: an implied structure is less marked than one that implies it. Thus, CV syllables are less marked than CGV syllables, and CGV syllables are less marked than CGGV syllables. I assume that the syllables in Table 1, which consists of CV(G/N) syllables, are less marked than those of Tables 2 and 3, which consist of CGV(G/N) syllables, and the syllables of Tables 2 and 3 are less marked than those of Table 4, which consists of CGGV(G/N) syllables. This markedness hierarchy would suggest the following implicational relationship between the four tables: a segment appearing in Table 2 or 3 is expected to appear in Table 1; a segment appearing in Table 4 is expected to appear in Tables 1, 2, and 3. Next I go through the four tables of distributions. I start with Table 1.

---

[7]The two prenuclear glides coalesce into one segment [ɥ] on the surface. I discuss this point in detail in Chapter 3, section 3.1.5.

Table 1 Syllables headed by plain consonants in Wuhan

	a	e	ɤ	o	i	u	ü	aj	ej	aw	ow	an	ən	ün	aŋ	oŋ	m̩	n̩	ŋ̍
p	pa		pɤ	po	pi	pu		paj	pej	paw		pan	pən		paŋ	poŋ			
p'	p'a		p'ɤ	p'o	p'i	p'u		p'ai	p'ej	p'aw		p'an	p'ən		p'aŋ	p'oŋ			
m	ma		mɤ	mo	mi			maj	mej	maw	mow	man	mən		maŋ	moŋ			
f	fa					fu			fej		fow	fan	fən		faŋ	foŋ			
t	ta		tɤ	to	ti			taj	tej	taw	tow	tan	tən		taŋ	toŋ			
t'	t'a		t'ɤ	t'o	t'i			t'aj	t'ej	t'aw	t'ow	t'an	t'ən		t'aŋ	t'oŋ			
n	na		nɤ	no	ni		nü	naj	nej	naw	now	nan	nən		naŋ	noŋ			
ʦ	ʦa		ʦɤ	ʦo	ʦɿ			ʦaj	ʦej	ʦaw	ʦow	ʦan	ʦən		ʦaŋ	ʦoŋ			
ts'	ts'a		ts'ɤ	ts'o	ts'ɿ			ts'aj	ts'ej	ts'aw	ts'ow	ts'an	ts'ən		ts'aŋ	ts'oŋ			
s	sa		sɤ	so	sɿ			saj	sej	saw	sow	san	sən		saŋ	soŋ			
r																			
ʨ					ʨi		ʨü							ʨün					
ʨ'					ʨ'i		ʨ'ü							ʨ'ün					
ȵ																			
ɕ					ɕi		ɕü							ɕün					
k	ka		kɤ	ko		ku		kaj		kaw	kow	kan	kən		kaŋ	koŋ			
k'	k'a		k'ɤ	k'o		k'u		k'aj		k'aw	k'ow	k'an	k'ən		k'aŋ	k'oŋ			
ŋ	ŋa		ŋɤ	ŋo				ŋaj		ŋaw	ŋow	ŋan	ŋən		ŋaŋ	ŋoŋ			
x	xa		xɤ	xo		xu		xaj		xaw	xow	xan	xən		xaŋ	xoŋ			
0	a		ɤ	o	i	u	ü										m̩	n̩	ŋ̍

In Table 1, we can see that palatals occur only with front vowels ([i] or [ü]; in Chapter 3 I will show that [ü] is actually the surface realization of two high vowels [i] and [u]); velars never appear with these vowels. This distribution is also found in the other three tables. In other words, palatals and velars are in complementary distribution. If palatals are treated as independent consonants, it is hard to explain why systematic gaps (see the four rows headed by palatals) are not found with the other consonants, but with palatals only. If palatals are treated as velars which are palatalized by the high front vowel [i], the gaps in the four rows disappear. Also, the only syllables we find with palatals are always followed by high front vowels, such as [tɕi], [tɕin], [tɕü], and [tɕün]. These fit exactly in the gaps in the four rows headed by velars, which otherwise would have to be left as accidental. Thus the complementary distribution of palatals and velars is the first piece of evidence that palatals are underlying velars.

Next I go through Table 2.

Table 2 Syllables headed by consonants with palatalization

	a	e	ɤ	o	i	u	ü	aj	ej	aw	ow	an	ən	ün	aŋ	oŋ	m̩	n̩	ŋ̍
pʲ	pʲa	pʲe								pʲaw			pʲən		pʲaŋ				
pʲ'	pʲ'a	pʲ'e								pʲ'aw			pʲ'ən		pʲ'aŋ				
mʲ		mʲe								mʲaw	mʲow		mʲən						
fʲ																			
tʲ	tʲa	tʲe								tʲaw	tʲow		tʲən		tʲaŋ	tʲoŋ			
tʲ'	tʲ'a	tʲ'e								tʲ'aw			tʲ'ən		tʲ'aŋ				
nʲ	nʲa	nʲe		nʲo						nʲaw	nʲow		nʲən		nʲaŋ				
tsʲ																			
tsʲ'																			
sʲ																			
rʲ																			
tɕ	tɕa	tɕe		tɕo						tɕaw	tɕow		tɕən		tɕaŋ	tɕoŋ			
tɕ'	tɕ'a	tɕ'e		tɕ'o						tɕ'aw	tɕ'ow		tɕ'ən		tɕ'aŋ	tɕ'oŋ			
ɲ	ɲa																		
ɕ	ɕa	ɕe		ɕo						ɕaw	ɕow		ɕən		ɕaŋ	ɕoŋ			
kʲ																			
kʲ'																			
ŋʲ																			
xʲ																			
j	ja	je		jo						jaw	jow		jən		jaŋ	joŋ			

In Table 2, palatalization appears with all consonants (including palatals) except velars (e.g. *[k^j]) and dentals (e.g. *[ts^j]). The lack of segments such as *[ts^j] can be treated as a complexity constraint in Wuhan and is discussed in detail in Chapter 3, section 3.1.3. However, the lack of segments such as *[k^j] is hard to explain, especially considering that palatalization is a very common process with velar consonants in languages of the world. Moreover, if we assume that the presence of palatals implies the presence of velars, we cannot explain why palatal consonants can fill in many cells in the more marked Table 2 without filling in the corresponding cells in the less marked Table 1. If surface palatals are treated as underlying velars palatalized by the high front vowel [i], the gaps in rows headed by velars in Table 2 as well as the markedness problem for surface palatals would all disappear.

Next I go through Tables 3 and 4.

Table 3 Syllables headed by consonants with labialization

	a	e	ɤ	o	i	u	ü	aj	ej	aw	ow	an	ən	ün	aŋ	oŋ	m̩	n̩	ŋ̩
pʷ																			
pʷ'																			
mʷ																			
fʷ																			
tʷ																			
tʷ'																			
nʷ																			
ʦʷ	ʦʷa							ʦʷaj	ʦʷej			ʦʷan			ʦʷaŋ				
tsʷ'	tsʷ'a							tsʷ'aj	tsʷ'ej			tsʷ'an			tsʷ'aŋ				
sʷ	sʷa		sʷɤ					sʷaj	sʷej			sʷan			sʷaŋ				
rʷ	rʷa							rʷaj	rʷej										
ʨʷ																			
ʨʷ'																			
ɳʷ																			
ɕʷ																			
kʷ	kʷa		kʷɤ					kʷaj	kʷej			kʷan	kʷən		kʷaŋ				
kʷ'	kʷ'a							kʷ'aj	kʷ'ej			kʷ'an	kʷ'ən		kʷ'aŋ				
ŋʷ																			
xʷ	xʷa		xʷɤ					xʷaj	xʷej			xʷan	xʷən		xʷaŋ				
w	wa							waj	wej			wan	wən		waŋ				

Table 4 Syllables headed by consonants with both palatalization and labialization

	a	e	ɤ	o	i	u	ü	aj	ej	aw	ow	an	ən	ün	aŋ	oŋ	m̩	n̩	ŋ̍
$p^{ɥ}$																			
$p^{ɥ'}$																			
$m^{ɥ}$																			
$f^{ɥ}$																			
$t^{ɥ}$																			
$t^{ɥ'}$																			
$n^{ɥ}$																			
$ts^{ɥ}$																			
$ts^{ɥ'}$																			
$s^{ɥ}$																			
$r^{ɥ}$																			
$tɕ^{w}$		$tɕ^{w}e$																	
$tɕ^{w'}$		$tɕ^{w'}e$																	
$ɲ^{w}$																			
$ɕ^{w}$		$ɕ^{w}e$																	
$k^{ɥ}$																			
$k^{ɥ'}$																			
$ŋ^{ɥ}$																			
$x^{ɥ}$																			
ɥ		ɥe											ɥən						

In Table 3, only velars and dentals take labialization, and in Table 4, only palatals take both palatalization and labialization. Again the markedness problem exists: palatals do not show up in the less marked Table 3, but do in the more marked Table 4. Similarly such a problem would disappear if palatals are treated as underlying velars with coronal secondary articulation.

Based on the complementary distribution of palatals and velars, and on syllable markedness, I conclude that surface palatals are underlying velars. Here I do not go into detail about how velars with a coronal secondary articulation surface as palatals. The interested reader is referred to Wu 1994, section 3.2 for details.

2.3 Conclusion

In this chapter I have outlined the theoretical framework I follow as well as some basic assumptions about Mandarin languages that relate to the study of vowel systems. In particular, I have presented the contrastive specification approach I pursue in the study. I have adopted feature geometry to structurally represent specifications. I have assumed that the Mandarin surface syllable template requires an obligatory binary-branching rime and an optional single-slot onset. In the next chapters I argue that contrastive specification accounts for distributional facts of Mandarin vowel systems in a simple and elegant way. While I survey the full vowel system, I focus in particular on the different patterns that Mandarin languages show with respect to the feature [Labial]. In all languages [Coronal] is active phonologically. In some languages, [Labial] is an active feature phonologically, while in others it is not. I argue that contrastive specification allows for exactly this type of asymmetry between [Coronal] and [Labial] with the difference between the languages in terms of the patterning of [Labial] depending on whether it is specified phonologically or not.

Chapter 3 Mandarin five-vowel inventories

In this chapter I examine Mandarin languages with five-vowel inventories. I have selected for discussion two representative languages, Wuhan and Linfen. I will show in particular how two identical phonological vowel inventories can be realized in different ways on the surface. In section 3.1 I examine the phonological vowel inventory of Wuhan. In section 3.2 I examine the phonological vowel inventory of Linfen. In section 3.3 I draw a conclusion for the chapter.

3.1 Wuhan

3.1.1 Consonant inventory

First I provide the consonant system of the language, both phonetic and phonological. The data for Wuhan come from Zhu 1992 and Chen & Li 1996.

(1) Phonetic consonants of Wuhan

		Labial	Alveolar	Dental	Palatal	Velar
Stops and affricates	-asp	p	t	ts	tɕ	k
	+asp	p'	t'	ts'	tɕ'	k'
Fricatives		f		s	ɕ	x
Sonorants		m	n	r	ɲ	ŋ

(2) Phonological consonants of Wuhan

		Labial	Alveolar	Dental	Velar
Stops and affricates	-asp	p	t	ts	k
	+asp	p'	t'	ts'	k'
Fricatives		f		s	x
Sonorants		m	n	r	ŋ

The arguments that surface palatals are not underlyingly present but are derived and the place specifications of each type of consonants are discussed in Chapter 2 and are not repeated.

3.1.2 Vowel inventory: phonetic

Next I introduce the vowel system. The surface vowel inventory is given below.

(3) Phonetic vowel inventory of Wuhan[8]

	Front		Central	Back	
	Unrounded	Rounded	Unrounded	Unrounded	Rounded
High	i	ü	ɿ		u
Mid	e		ə	ɤ	o
Low			a		

The vowel [ɿ] requires some discussion, together with [ʅ], which does not exist in Wuhan but is found in the other languages soon to be discussed. In the traditional Chinese literature (Cheng 1973; Xu 1980; Wang 1985; Lin 1989, among others), [ɿ] and [ʅ] are called "apical vowels" (Ladefoged and Maddieson 1996 call them "fricative vowels"). Their articulation involves the tip of the tongue. Articulatorily, [ɿ] and [ʅ] are regarded as vocalic continuation of the apical (dental and retroflex) consonants. In other words the existence of these two vowels totally depends on the consonants. In this thesis I adopt the traditional treatment of these vowels. In Wuhan dental consonants but not retroflexes are found. Thus only [ɿ] is found, as the continuation of a dental consonant.

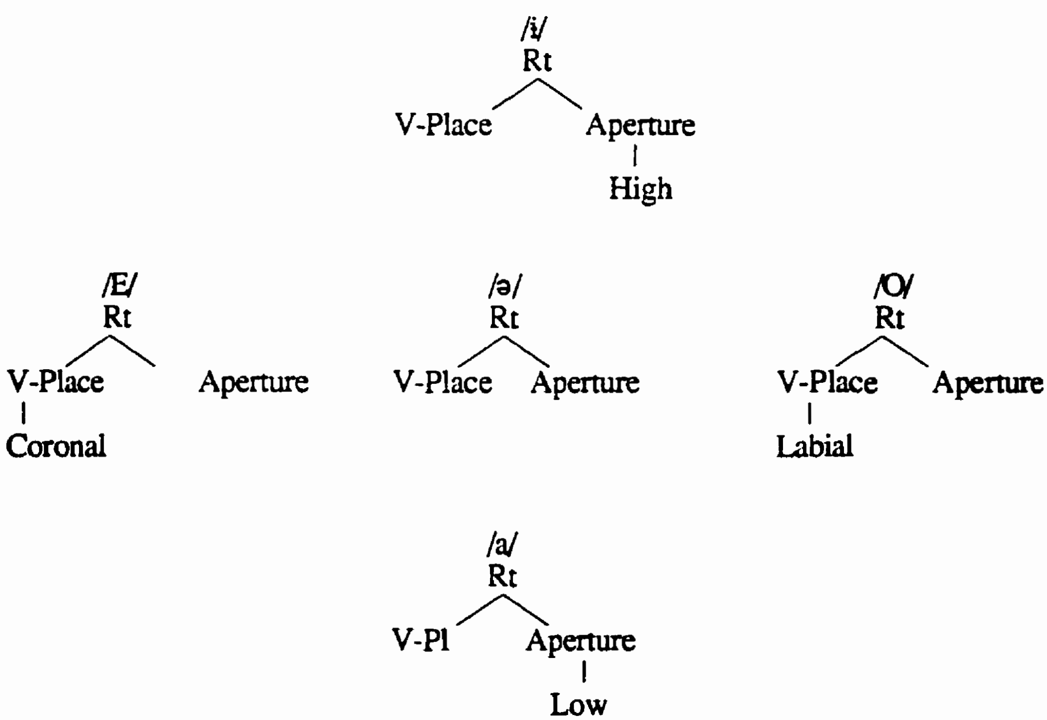
[8] There are two vowels which are not included in this chart, [ɛ] and [ɔ]. These two vowels are described in Zhu 1992 but are not listed in Chen & Li 1996. According to Zhu 1992, these vowels only occur in r-suffixed words. That is, they are only found in lexically derived environments. More specifically, when the suffix *-r* is attached to a stem, it causes changes in the vowel of the stem, creating the two vowels. The two vowels do not affect my analysis of the phonological vowel inventory of Wuhan, and I do not include them in my discussion.

Lastly, unlike the other surface vowels, I argue that the front rounded vowel [ü] is not derived from a single vowel. I will argue later that this vowel is a complex vowel, which comes from the coalescence of the vowels [i] and [u].

The other surface vowels in the table are straightforward and need no more comment. Now I turn to establishing the phonological vowel inventory of Wuhan.

Based on the distributional patterns of the vowels in table (3), I propose that the Wuhan vowel system derives from the following five phonological vowels, shown in structural terms:

(4) Proposed phonological vowel inventory of Wuhan



I will refer to these vowels as /E/, etc., as indicated by the vowel above the structure. In this system there is a front vowel /E/, carrying the feature Coronal, a high central vowel /ɨ/, carrying High, a mid central vowel /ə/, with no features, a mid back vowel /o/, marked Labial, and a low central vowel /a/, marked Low. The vowel that I call /E/ here generally surfaces as [i]; see section 3.1.3.1 for discussion.

Now I go through the distributional patterns of the vowels in Wuhan and show why I propose the above phonological vowel inventory, and how the underlying representations map to the surface representations. Since there are two aspects of vowel features involved, place features and height features, I discuss them separately. I first justify the place specifications. For reference to full vowel inventories, see Appendix 2.

3.1.3 Place specifications

I propose that the front vowel /E/ is specified with the place feature Coronal and the back vowel /o/ is specified with the feature Labial. I also propose that the other three central vowels /ɨ/, /ə/, and /a/ are unspecified for place (see section 2.1.2 of Chapter 2 for this assumption). I repeat the place specifications of the five vowels. See section 3.1.4 for discussion of height features.

(5) Place specifications of Wuhan vowels

/E/	/O/	/ɨ/, /ə/, /a/
Rt	Rt	Rt
|	|	|
V-Place	V-Place	V-Pl
|	|	
Coronal	Labial	

First of all, I show how the five proposed phonological vowels in (4) surface as the phonetic vowels in (3).

(6) How phonological vowels surface in Wuhan

/E/ -->	[ɿ]	after a dental consonant
	[i]	elsewhere
/ɨ/ -->	[u]	(assimilation in nucleus, default Labial in onset and coda)
/ə/-->	[e]	following or preceding glide [j]
	[ɤ]	in open syllable but not following glide [j]
	[ə]	elsewhere
/O/-->	[o]	
/a/-->	[a]	

Recall from Chapter 2 that there are two factors that trigger the underlying presence of a feature. One factor is that language-particular phonological behavior requires that the feature be present and the other factor is that the contrasts in the system force the feature to be present. By examining how each of the proposed underlying vowels surfaces, I will justify the overall place contrasts in the system as well as the activeness of certain place feature(s) in the system. Next I examine the five vowels one by one, starting from surface high vowels.

3.1.3.1 /E/ --> [ɿ], [i]

The vowel /E/ has two surface forms, [ɿ] and [i]. The distribution of [ɿ] is very limited, as shown in (7). The tables showing distribution are all presented as follows. The first column shows the consonants at the different places of articulation. The top row of each table shows the full set of rimes in which the vowel under discussion appears. These are sometimes given in the underlying form (enclosed in slashes), and sometimes in surface form (no brackets). The syllabification in the foilowing tables, and in tables thereafter, follows the Mandarin syllable structures as discussed in section 2.2.1 of Chapter 2. Recall that /E/ generally surfaces as a high vowel; see section 3.1.4.

(7) Distribution of [ɿ]

	/E/
p	
p'	
m	
f	
t	
t'	
n	
ts	tsɿ
ts'	ts'ɿ
s	sɿ
r	
k	
k'	
ŋ	
x	
0	

That is, [ɿ] is only found *in the nuclear position in an open syllable following a dental consonant*. It is in complementary distribution with anther vowel [i]. It is easier to present the distribution of [i] according to the syllable position it appears in. Below I show how [i] is distributed in the nucleus, the onset, and the coda positions.[9]

[9]When /E/ occurs in the onset or the coda, i.e., the non-nucleus, it is a glide and so is written [j]. Further, when it occurs in the onset with a preceding consonant, it is a secondary articulation on this consonant and is written as a superscripted [j].

(8) Distribution of [i]

<u>(8A) [i] appears in the nucleus</u>

	/E/
p	pi
p'	p'i
m	mi
f	
t	ti
t'	t'i
n	ni
ʦ	
ʦ'	
s	
r	
k	ʨi
k'	ʨ'i
ŋ	
x	ɕi
0	i

In tables (8B) and (8C), while the heading column gives underlying forms, the heading row gives surface forms. Later discussion will reveal their underlying forms. Recall from Chapter 2 that when /E/ precedes another vowel it is syllabified as a secondary articulation on the onset and when it follows another vowel it is syllabified in the coda. Systematic gaps are discussed later in this section.

(8B) [i] appears in the onset

	ʲa	ʲe	ʲo	ʲaw	ʲəw	ʲən	ʲaŋ	ʲoŋ
p	pʲa	pʲe		pʲaw		pʲən	pʲaŋ	
p'	pʲ'a	pʲ'e		pʲ'aw		pʲ'ən	pʲ'aŋ	
m		mʲe		mʲaw	mʲəw	mʲən		
f								
t	tʲa	tʲe		tʲaw	tʲəw	tʲən	tʲaŋ	tʲoŋ
t'	tʲ'a	tʲ'e		tʲ'aw		tʲ'ən	tʲ'aŋ	
n	nʲa	nʲe	nʲo	nʲaw	nʲəw	nʲən	nʲaŋ	
ʦ								
ts'								
s								
r								
k	ʨa	ʨe	ʨo	ʨaw	ʨəw	ʨən	ʨaŋ	ʨoŋ
k'	ʨ'a	ʨ'e	ʨ'o	ʨ'aw	ʨ'əw	ʨ'ən	ʨ'aŋ	ʨ'oŋ
ŋ	ŋa							
x	ɕa	ɕe	ɕo	ɕaw	ɕəw	ɕən	ɕaŋ	ɕoŋ
j	ja	je	jo	jaw	jəw	jən	jaŋ	joŋ

systematic gaps

(8C) [i] appears in the coda

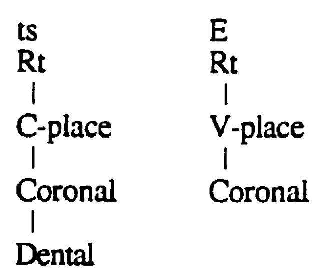
	aj	ej	ʷaj	ʷej
p	paj	pej		
p'	p'aj	p'ej		
m	maj	mej		
f		fej		
t	taj	tej		
t'	t'aj	t'ej		
n	naj	nej		
ʦ	ʦaj	ʦej	ʦʷaj	ʦʷej
ts'	ts'aj	ts'ej	tsʷ'aj	tsʷ'ej
s	saj	sej	sʷaj	sʷej
r			rʷaj	rʷej
k	kaj		kʷaj	kʷej
k'	k'aj		kʷ'aj	kʷ'ej
ŋ	ŋaj			
x	xaj		xʷaj	xʷej
w			waj	wej

systematic gaps

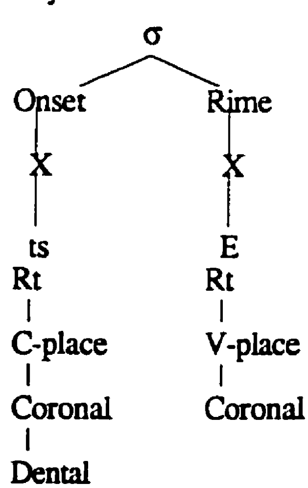
As shown in (8A), when [i] is in the nucleus, it occurs with all the other consonantal places of articulation except dental consonants. It is in complementary distribution with the vowel [ɿ], which only occurs in the nucleus following a dental consonant. For this reason, I treat [i] and [ɿ] as two surface forms of one phoneme /E/. /E/ surfaces as [ɿ] after a dental consonant as a result of assimilation, as shown in (9).The vowel /E/ is specified with the place feature Coronal (to be examined next). In the derivations here and throughout, (a) shows the proposed underlying form, (b) the form after syllabification, and (d) the surface form that results due to the application of phonological rules. I assume that syllabification takes place at an early stage, before phonological rules. As we shall see further, phonological processes in Mandarin languages need to refer to syllable positions.

(9) How /E/ surfaces as [ɿ] after a dental consonant

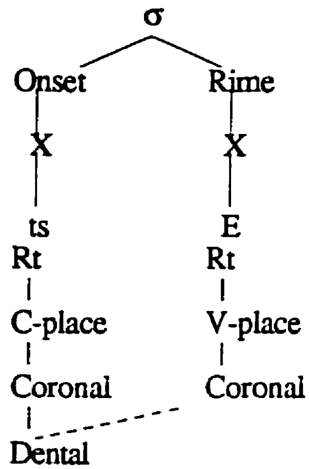
(a) Underlying /tsE/



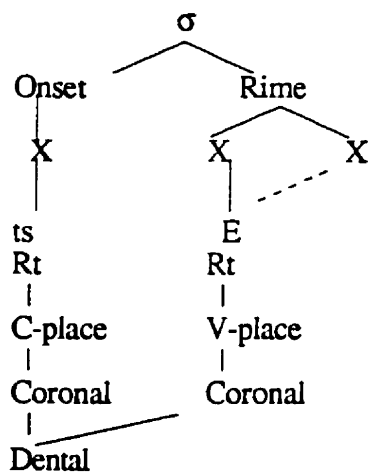
(b) After syllabification



(c) Spreading from /ts/ to /E/[10]



(d) Lengthening of /E/



(e) Surface: [tsɿ] ("son")

Above after /ts/ spreads its place feature onto /E/, /E/ is lengthened to take both timing slots of the rime, so as to meet the surface syllable structure requirement in Mandarin. Hence [tsɿ]. I follow the Mandarin practice in writing these surface lengthened vowels with a single vowel; so [tsɿ] is really [tsɿ:].

---

[10]After spreading, the default rule of inserting High applies to /E/. I address this point in section 3.1.4.

The distribution of the two surface forms of /E/ in the nucleus is summarized in (10).

(10) Distribution of [i] and [ɿ] in the nucleus as two surface variants of /E/

	/E/
p	pi
p'	p'i
m	mi
f	
t	ti
t'	t'i
n	ni
ʦ	ʦɿ
ts'	ts'ɿ
s	sɿ
r	
k	ʨi
k'	ʨ'i
ŋ	
x	ɕi
0	i

To summarize the vowel /E/, this vowel is realized as [ɿ] only when it is syllabified in the nucleus and follows a dental consonant, and is a result of place assimilation. In environments other than this, /E/ is realized as [i]/[j]. /E/ is specified with the place feature Coronal. Later on when I discuss the mid central vowel /ə/, I will show that Coronal is specified because it is active in phonological patterning.

I now turn to the cells that I have labeled systematic gaps in (8B) and (8C). Sequences such as *[ts^j] (in 8b) and *[p^w] (in 8c) are missing in Wuhan. I propose that these gaps are systematic and can be explained in terms of the Obligatory Contour Principle (*[p^w]) and complexity constraints (*[ts^j]).[11] Here I refer to McCarthy 1986:208 for a definition of the OCP.

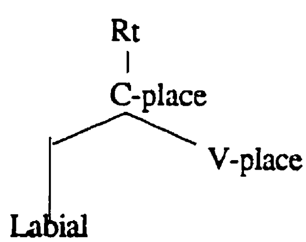
[11] As can be seen from (9C), [w] is never a secondary articulation on alveolar consonants. Gaps *[Alveolar^w] are unique to Wuhan and I do not attempt to explain them here.

"At the melodic level, adjacent identical elements are prohibited."

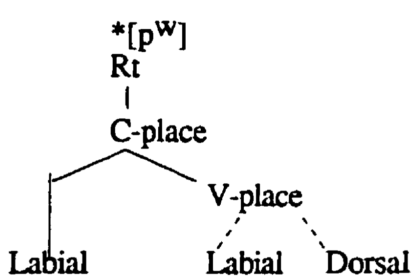
For our purposes here, "identical elements" can be interpreted as "identical features". That is, when two identical features are adjacent, either at the underlying or the surface levels, they are ruled out by the OCP. First, I show how *$[p^w]$ is ruled out. Since I have not discussed [w] yet, I assume for the moment that its underlying form is /ɨ/, which is unspecified for place feature and surfaces by default rules, which insert the features Labial and Dorsal (see section 3.1.3.2). Thus the underlying form of $[p^w]$ is /$p^{\text{ɨ}}$/. Below I show how *$[p^w]$ is ruled out by the OCP. In (11) and other examples I give representations following syllabification in (a).

(11) OCP violation in *$[p^w]$

(a) Underlying structure: /$p^{\text{ɨ}}$/



(b) Default rule of Labial and Dorsal on /ɨ/ on the surface: OCP violated



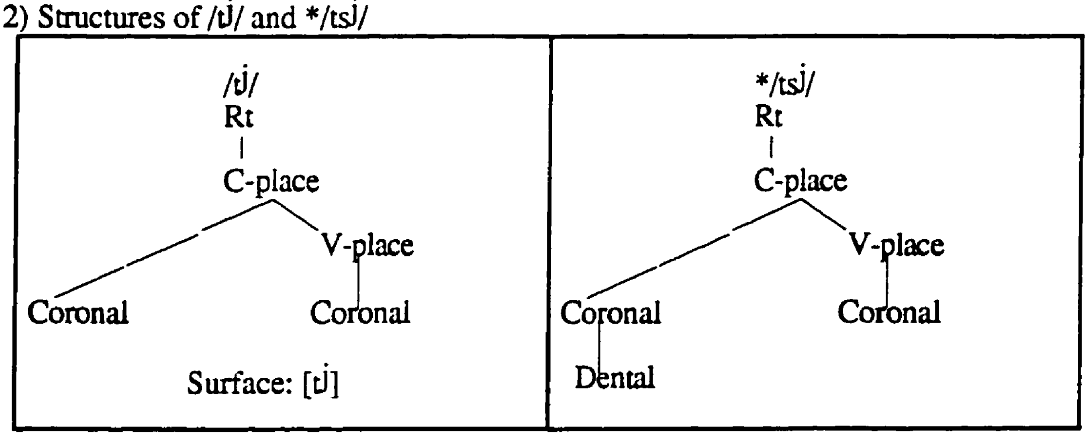
<-- OCP violation

At the underlying level as in (11a), there is only one Labial feature, which is associated with /p/. The structure is fine in that it creates no OCP violation. However, after Labial and Dorsal are inserted by default on /ɨ/ in (11b) (see discussion of the vowel /ɨ/ in section 3.1.3.2), two Labial features are adjacent to each other. The OCP is violated. The sequence *[p^w] is thus ruled out.

Thus in Wuhan and other Mandarin languages two Labial features within one segment are not allowed by the OCP. This accounts for the absence of labialized labials.

Now I address the other gap, *[tsj]. Here I need to mention a similar sequence, [tj]. In table (8b), sequences such as *[tsj] are missing, but sequences such as [tj] are found. I show the underlying structures of both below for comparison.

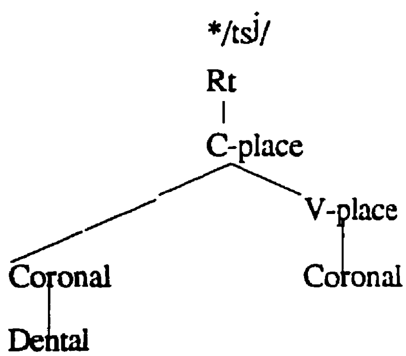
(12) Structures of /tj/ and */tsj/



In both structures above two adjacent Coronal features are found. However, why is /tj/ allowed while */tsj/ is not allowed in Wuhan?

I propose that it is particular to Wuhan (and to Mandarin in general as well, as shall be seen) that two Coronal features within one segment are not necessarily ruled out by the OCP, unlike two Labial features within one segment. The OCP thus must make reference to particular features. It rules out [Labial]-[Labial] on a particular segment but allows [Coronal]-[Coronal]. However, not all consonants can take palatalization, as shown in (12). I propose that palatalized dentals are ruled out by a structural complexity constraint which disallows palatalization of a complex primary articulation. I express this constraint below.

(13) Structural complexity constraint for Wuhan



That is, in Wuhan a consonant cannot support palatalization if the place node of the consonant has a dependent node underneath, i.e., is too complex. Thus */ts^j/ is ruled out by this constraint, while /t^j/ is fine. Notice /p^{ɨ}/ ([p^w]) is allowed by this constraint because it contains no coronal feature; it is the OCP that rules this out.

I have suggested above that it is language particular to Wuhan that the threshold of coronal palatalization falls between /t^j/ and */ts^j/, which is determined by structural complexity, as shown below.

(14) Threshold of coronal palatalization in Wuhan

/t^j/ | */ts^j/

I further suggest that the palatalization threshold could vary among languages, with the following results predicted:

(15) Predicted patterns of coronal palatalization

We find languages with:	We do not find languages with:
*tj; *tsj tj; *tsj tj; tsj	*tj; tsj

That is, it is possible to find languages which do not allow either one (*tj; *tsj), or allow only one (tj; *tsj), or allow both (tj; tsj). However, it is not possible to find languages which allow /tsj/ but not /tj/. In other words, more complex structures imply less complex structures (see Rice and Avery 1993, Prince and Smolensky 1993, among others).

To briefly summarize, I have shown the distribution of the vowel /E/. It surfaces as [ɪ] after a dental consonant, and as [i] elsewhere. I have also discussed some systematic gaps of complex segments found in the distribution of /E/. Next I discuss the phoneme /ɨ/.

3.1.3.2 /ɨ/ --> [u]

The existence of the vowel /ɨ/ is related to the distribution of the surface vowel [u]. The distribution of [u] in Wuhan is interesting, and different from that in other languages to be discussed later.

(16) Distribution of [u] in Wuhan

a) [u] in Nucleus		b) [u] in Coda				c) [u] in Onset						
	u	aw	ow	jaw	jow	^{w}a	^{w}ɤ	^{w}aj	^{w}ej	^{w}an	^{w}ən	^{w}aŋ
p	pu	paw		p^{j}aw								
p'	p'u	p'aw		p^{j}'aw								
m		maw	mow	m^{j}aw	m^{j}ow							
f	fu		fow									
t		taw	tow	t^{j}aw	t^{j}ow							
t'		t'aw	t'ow	t^{j}'aw								
n		naw	now	n^{j}aw	n^{j}ow							
ʦ		ʦaw	ʦow			ʦ^{w}a		ʦ^{w}aj	ʦ^{w}ej	ʦ^{w}an		ʦ^{w}aŋ
ts'		ts'aw	ts'ow			ts^{w}'a		ts^{w}'aj	ts^{w}'ej	ts^{w}'an		ts^{w}'aŋ
s		saw	sow			s^{w}a	s^{w}ɤ	s^{w}aj	s^{w}ej	s^{w}an		s^{w}aŋ
r						r^{w}a		r^{w}aj	r^{w}ej			
k	ku	kaw	kow	ʨaw	ʨow	k^{w}a	k^{w}ɤ	k^{w}aj	k^{w}ej	k^{w}an	k^{w}ən	k^{w}aŋ
k'	k'u	k'aw	k'ow	ʨ'aw	ʨ'ow	k^{w}'a		k^{w}'aj	k^{w}'ej	k^{w}'an	k^{w}'ən	k^{w}'aŋ
ŋ		ŋaw	ŋow									
x	xu	xaw	xow	ɕaw	ɕow	x^{w}a	x^{w}ɤ	x^{w}aj	x^{w}ej	x^{w}an	x^{w}ən	x^{w}aŋ
0	u			jaw	jow	wa		waj	wej	wan	wən	waŋ

[shaded box] systematic gaps

When syllabified in an onset (16c) or a coda (16b), i.e., a non-nucleus, [u] appears quite freely. That is, [u] is found with all types of consonants. However, when syllabified in the nucleus (16a), the distribution of [u] is quite limited. In particular, [u] only appears after a labial or a dorsal consonant, and never after an alveolar or dental consonant.[12]

Given the distributional pattern of [u], there are two choices regarding the underlying form of this vowel. The first choice is that the underlying form is /u/, specified with the place

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[12]There is one exception, the syllable [u], which is onsetless. As will be seen in a moment, I propose that the underlying form of [u] is /ɨ/. When syllabified in the nucleus, /ɨ/ generally surfaces through assimilation to the preceding consonant. However, when there is no onset consonant, I propose /ɨ/ surfaces through default, the same way as /ɨ/ surfaces in the non-nucleus.

feature Labial. In this way /u/ surfaces directly as [u]. The problem with this choice is that it is hard to explain why [u] is so limited in distribution in the nucleus. That is, why does [u] only occur with labial or dorsal consonants when in the nucleus, but with all types of consonants when in the non-nucleus?

The other choice is that, given the fact that the nuclear [u] seems to be conditioned by the preceding consonant and seems to be a result of place assimilation to the consonant ([u] being both round and back, sharing features with both labial and dorsal consonants; see the representation in (14) in Chapter 2), the underlying form is /ɨ/, which is placeless and thus available as a target for place assimilation (see Chapter 2). Once the limited distribution of [u] in the nucleus is explained, then we need to explain why [u] is so freely distributed (found with all types of onset consonants) in the onset and coda. I propose that unlike in the nucleus, /ɨ/ cannot assimilate to an onset consonant when in the onset or coda. I explain this next.

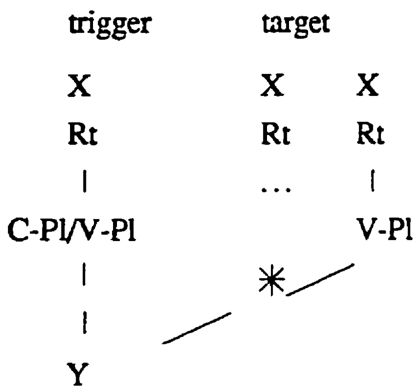
First, when [u] appears in the coda, it does not assimilate to the consonant in the onset. I propose that this can be explained by a constraint on locality of assimilation in Wuhan, as expressed in (17).

(17) Constraint on locality in assimilation in Wuhan ("C-Pl/V-Pl" means either C-Place or V-Place)

```
trigger        target
X              X
Rt             Rt
 |              |
C-Pl/V-Pl      V-Pl
 |
 |_ _ _ _ _ _ _
Y
```

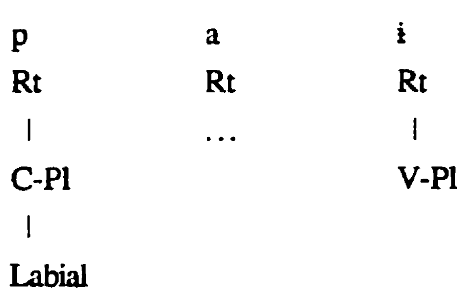
Above "X" stands for a segment and "Y" stands for a feature. The trigger has to be adjacent to the target at the segmental level. In other words, a trigger cannot spread a feature onto a target if there is another segment in between, as shown in (18). See Archangeli and Pulleyblank 1993 for a similar idea.

(18) Trigger and target not adjacent on segment level: spreading blocked



I illustrate with [paw] to show why spreading does not occur in this case. Under the hypothesis that [u] is /ɨ/, the underlying form of [paw] is /paɨ/.

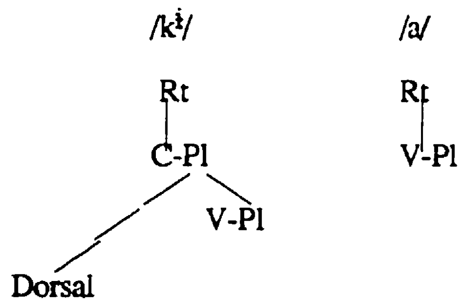
(19) Spreading does not happen between /p/ and /ɨ/ in Wuhan: lack of locality



As we see above, /p/ and /ɨ/ are not adjacent to each other at the segment level. Thus /ɨ/ does not assimilate in place to /p/.[13] This locality requirement holds for all assimilation processes in the Mandarin languages under study, including assimilation between consonant and vowel, and assimilation between vowel and vowel. This will be further seen as the thesis is developed.

Having explained why /ɨ/ in the coda does not assimilate to the onset consonant, now I explain why /ɨ/ in the onset does not assimilate to the onset consonant. I take $[k^{w}a]$ as an example. The form after syllabification of $[k^{w}a]$ is $/k^{ɨ}a/$ under the present hypothesis. I show the structure of this word in (20).

(20) Structure of $/k^{ɨ}a/$ after syllabification



Locality is not a problem for assimilation in the above structure since the consonantal feature and V-place are in the same segment. I assume that in Mandarin languages, assimilation cannot take place within one segment since /k/ and /ɨ/ are one segment, with /ɨ/ being a secondary articulation on /k/; and thus no assimilation is allowed.

---

[13]One might ask why in this case the feature Labial on /p/ does not spread onto /a/ instead. In section 4.3 of Chapter 4, I will explain why the central vowel /a/ does not assimilate in place to other segments (consonant or vowel).

I have shown that /ɨ/ cannot assimilate to the onset consonant when in the coda (locality requirement) or when in the onset (assimilation impossible within segment). Since the conditions for assimilation are not met, I propose that /ɨ/ surfaces through default in these two positions. Labial is the default feature.[14] Later when I discuss the vowel /ə/, I will bring in more evidence to show that the feature Labial is inert and thus unspecified on [u] in Wuhan.

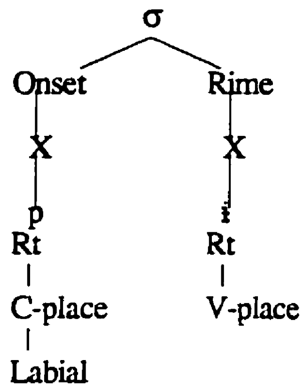
To summarize the above hypothesis regarding [u], I propose that the underlying form is /ɨ/. When in the nucleus, /ɨ/ surfaces as [u] by assimilating to the place of articulation of the preceding consonant. When in the onset or coda, /ɨ/ surfaces as [u] by default insertion of Labial, as assimilation cannot occur into these two positions. Next I show in detail how this hypothesis works.

First, nuclear [u] is only found after a labial or dorsal consonant. I argue that this pattern results from a process of assimilation. I show how /ɨ/ surfaces as [u] in (21). I ignore height features here; see section 3.1.4.

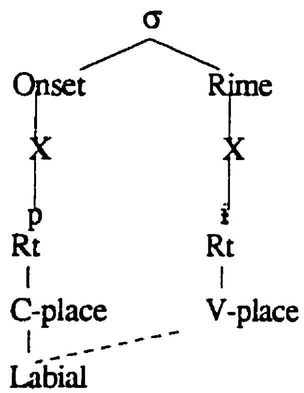
[14]And Dorsal as well. I will show in a moment that these two features imply each other and are both default features in Wuhan.

(21) How /ɨ/ becomes [u] after a labial consonant

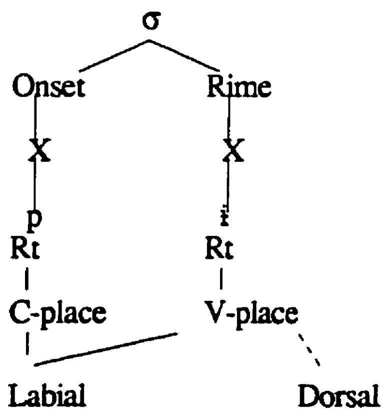
(a) /pɨ/ after syllabification



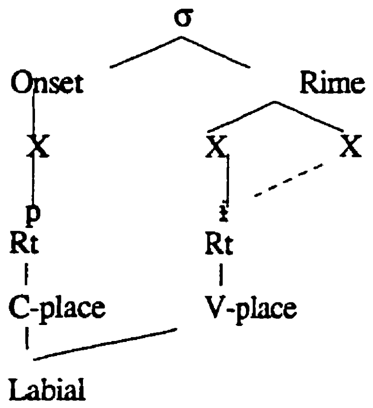
(b) Spreading



(c) Default insertion



(d) Lengthening of /ɨ/



(e) Surface: [pu] ("fabric")

In (21b) /p/ spreads its feature Labial onto the placeless /ɨ/. In (21c) Dorsal is inserted as default onto /ɨ/. This is because in Wuhan there is only one high back vowel which is round and only one high round vowel which is back (this vowel is [u]). So the features Labial and Dorsal are predictable from each other, leading to the two default rules in (22):

(22) Two default rules for high vowels in Wuhan

a) $[\text{Labial}]_{\text{V-place}} \rightarrow [\text{Dorsal}]_{\text{V-place}}$

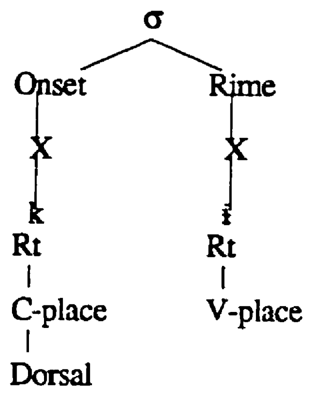
b) $[\text{Dorsal}]_{\text{V-place}} \rightarrow [\text{Labial}]_{\text{V-place}}$

Further, in (21d) /ɨ/ is lengthened to meet the surface syllable structure of Mandarin. The syllable surfaces as [pu].

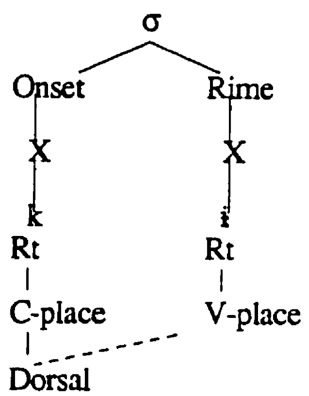
Next I show how /ɨ/ surfaces as [u] when preceded by a dorsal consonant.

(23) How /ɨ/ becomes [u] after a dorsal consonant

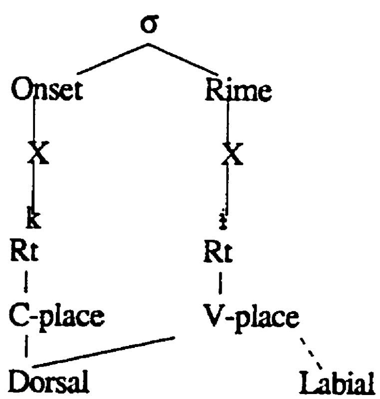
(a) /kɨ/ after syllabification



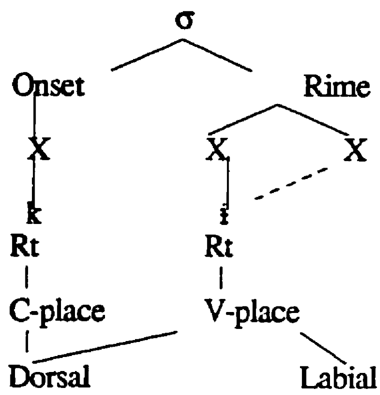
(b) Spreading



(c) Default insertion



(d) Lengthening of /ɨ/



(e) Surface: [ku] ("aunt")

In (23b) /k/ spreads its feature Dorsal onto /ɨ/. In (23c) Labial is inserted onto /ɨ/ as default (see (22b)). In (23d) /ɨ/ is lengthened. In (23e) the syllable surfaces as [ku].

I summarize the distribution of /ɨ/ in (24).

(24) Distribution of /ɨ/ in the nucleus

	/ɨ/
p	pu
p'	p'u
m	
f	fu
t	
t'	
n	
ts	
ts'	
s	
r	
k	ku
k'	k'u
ŋ	
x	xu

In (24) we see that when /ɨ/ follows a labial or a dorsal consonant, it assimilates in place to the consonant and surfaces as [u]. A question is: if /ɨ/ can assimilate to a labial or a dorsal consonant, can it also assimilate to an alveolar or dental consonant as well? The answer should be yes. Then what would be the surface results? I show the relevant processes in (25).

(25) How /ɨ/ surfaces after an alveolar consonant (syllabification ignored; lengthening of /ɨ/ ignored)

(a) Underlying

```
t            ɨ
Rt           Rt
|            |
C-place      V-place
|
Coronal
```

(b) Spreading Coronal

```
t            ɨ
Rt           Rt
|            |
C-place      V-place
|  - - - - - -
Coronal
```

(c) Surface: [ti] ("low")

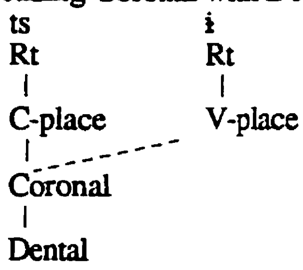
When /ɨ/ follows an alveolar consonant, it surfaces as [i].

(26) How /ɨ/ surfaces after a dental consonant (syllabification ignored; lengthening of /ɨ/ ignored)

(a) Underlying

```
ts           ɨ
Rt           Rt
|            |
C-place      V-place
|
Coronal
|
Dental
```

(b) Spreading Coronal with Dental



(c) Surface: [tsɿ] ("purple")

When /ɨ/ follows a dental consonant, it surfaces as [ɿ].

Recall that I showed in section 2.1.3.1 how the two surface vowels [i] and [ɿ] are derived from /E/, and in (25) and (26) we see how they derive from /ɨ/ as well. This means a surface form could be derived from two sources. That is, surface [ɿ] and surface [i] (after alveolar consonant only) can either come from /E/ or /ɨ/. Put another way, two different inputs, going through different processes, could come out being identical with each other.

I summarize the distribution of /ɨ/ in the nucleus in (27).

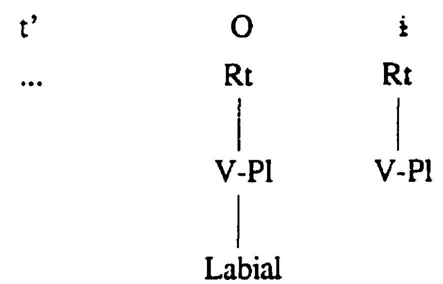
(27) How /ɨ/ surfaces as [u], [i], [ɿ] in the nucleus

	/ɨ/
p	pu
p'	p'u
m	
f	fu
t	ti
t'	t'i
n	ni
ts	tsɿ
ts'	ts'ɿ
s	sɿ
r	
k	ku
k'	k'u
ŋ	
x	xu

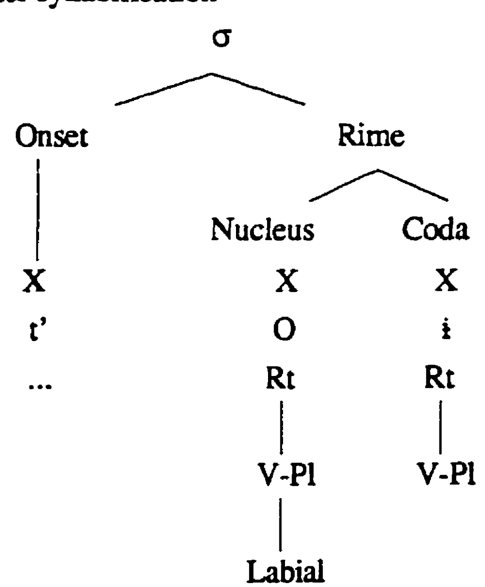
Having shown that it is possible that a sequence such as [ti] can be derived from two different underlying sources (/tɨ/ or /ti/), I address an additional question, which can be answered in a similar way: does /ɨ/ ever assimilate to a vowel? I have argued that when /ɨ/ is syllabified in the non-nucleus, it surfaces by the default rule which inserts Labial and Dorsal. However, in the sequence /Oɨ/ (see section 3.1.3.4 for discussion of the phoneme /O/), in which /O/ is syllabified in the nucleus and /ɨ/ in the coda, I argue that it is possible that /ɨ/ assimilates to the place of /O/, as shown below.

(28) How /t'Oɨ/ surfaces as [t'ow]: assimilation of /ɨ/ to /O/

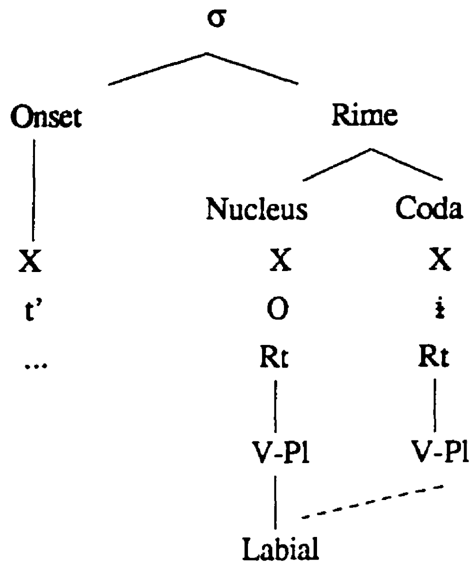
(a) Underlying /t'Oɨ/



(b) After syllabification



(c) Spreading of Labial from /O/ to /ɨ/



(d) Surface form: [t'ow] ("head")

In (28c), /O/ spreads Labial onto /ɨ/. Hence [t'ow]. Notice in this case the nucleus is a trigger rather than a target.

Thus the sequence /Oɨ/ can surface either through the default rule which inserts Labial and Dorsal on /ɨ/, as argued earlier, or through place assimilation of /ɨ/ to /O/, as shown in (28).

To summarize /ɨ/, based on its different distribution in different syllable positions, surfaces in two ways. In the nucleus, it assimilates to the preceding consonant and takes on the place feature of the consonant. In the onset and coda, conditions for assimilation to the onset consonant are not met for two different reasons. /ɨ/ thus surfaces through default Labial and Dorsal insertion and consistently surfaces as [u] (except the special case of /Oɨ/, in which /ɨ/ can surface as [u] in two different ways, either by default Labial and Dorsal, or by assimilating to the nucleus /O/).

3.1.3.3 /ə/--> [e], [ɤ], [ə]

The third vowel /ə/ has three surface realizations: [e], [ɤ], and [ə], which are in complementary distribution. More specifically, [e] is found when there is a preceding or following glide [j], [ɤ] in an open syllable but not preceded by the glide [j], and [ə] in other environments. Based on the distributional patterns, I treat the three vowels as three surface variants of /ə/. I show below how each variant is derived.

The variant [e] occurs when there is a preceding or following glide [j]. I show the relevant data in (29).

(29) Distribution of [e]: following or preceding [j]

	/əE/	/ᴱə/	/ᴱⁱə/
p	pej	pʲe	
p'	p'ej	pʲ'e	
m	mej	mʲe	
f	fej		
t	tej	tʲe	
t'	t'ej	tʲ'e	
n	nej	nʲe	
ʦ	ʦej		
ts'	ts'ej		
s	sej		
r			
k		ʨe	ʨʷe
k'		ʨ'e	ʨʷ'e
ŋ			
x		ɕe	ɕʷe
0		je	ɥe

systematic gaps

I have not discussed the complex vowel [ɥ] yet. I assume for the moment that it results from coalescence from the two vowels [i] and [u] (see section 3.1.4). Thus [ɥ] patterns in the same way as [j] in the above table.

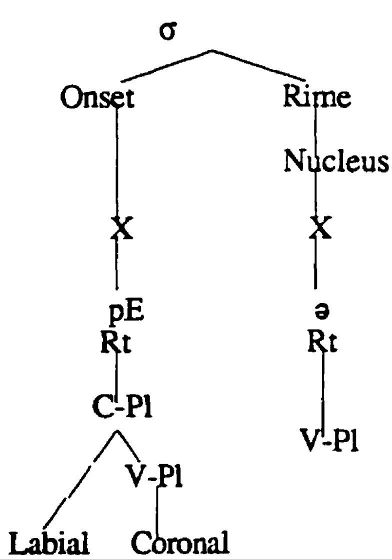
The distribution in (29) shows that the front vowel [e] is always found adjacent to another front glide [j]. I treat this as a result of place assimilation. I show the processes in (30) and (31). The first situation is progressive spreading. I take [pje] as an example. The underlying form is /piə/.

(30) How [e] is derived from /ə/: situation 1

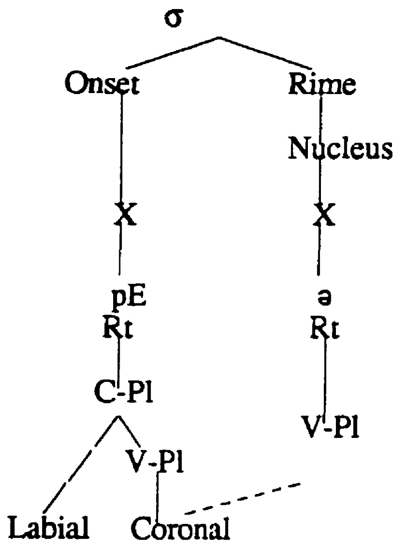
(a) Underlying /pEə/

p	E	ə
Rt	Rt	Rt
|	|	|
C-Pl	V-Pl	V-Pl
|	|	
Labial	Coronal	

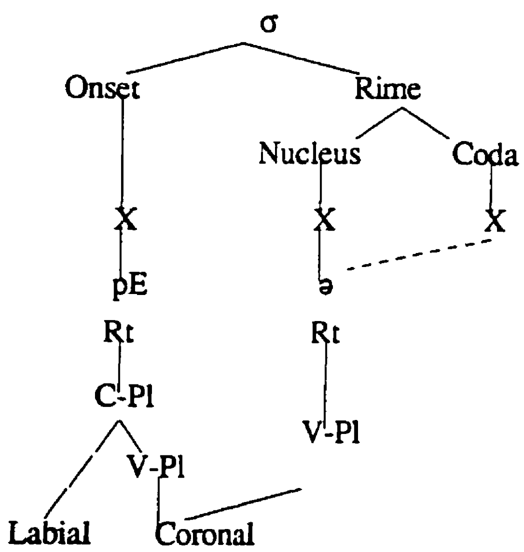
(b) After syllabification



(c) Spreading of Coronal



(d) Open syllable vowel lengthening



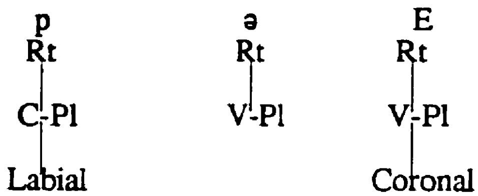
(e) Surface form: [pʲe] ("flat")

In (30c) /E/ spreads its place feature Coronal <u>progressively</u> onto /ə/. In (d) /ə/ is lengthened to take both timing slots of the rime so as to meet the surface syllable structure requirement of Mandarin. Hence [pʲe].

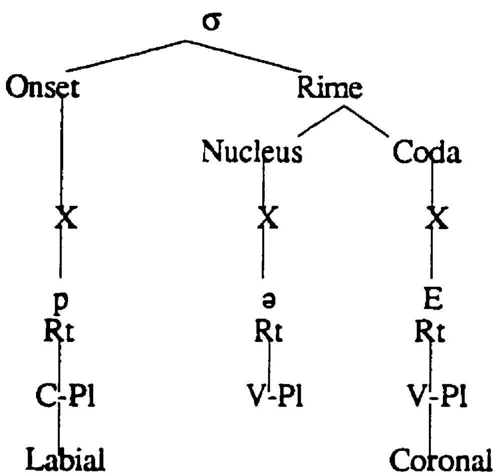
The second situation is regressive spreading. I take [pej] as an example. The underlying form is /pəE/.

(31) How [e] is derived from /ə/: <u>situation 2</u>

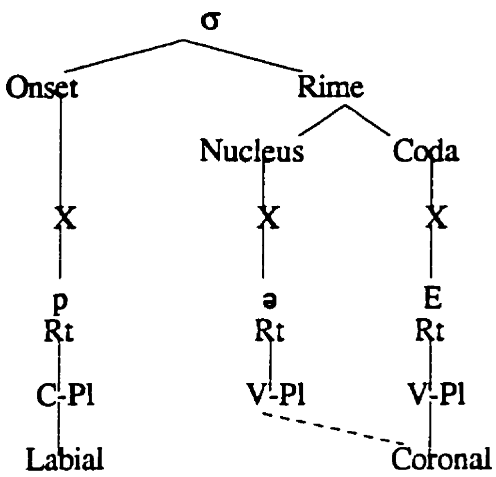
(a) Underlying /pəE/



(b) After syllabification



(c) Spreading of Coronal from /E/ to /ə/



(d) Surface form: [pej] ("north")

In this case /E/ spreads the place feature Coronal regressively onto /ə/, resulting in [pej].

The second variant of /ə/, [ɤ], occurs in an open syllable but not preceded by glide [j]. I present the relevant data below.

(32) Distribution of [ɤ]: in an open syllable but not preceded by [j]

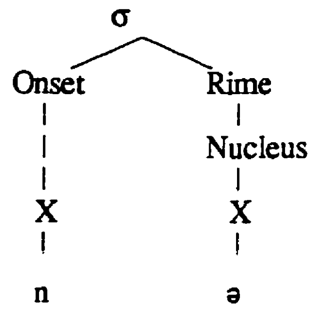
	/ə/	/ʷə/
p	pɤ	
p'	p'ɤ	
m	mɤ	
f		
t	tɤ	
t'	t'ɤ	
n	nɤ	
ts	tsɤ	
ts'	ts'ɤ	
ʂ	ʂɤ	ʂʷɤ
r		
k	kɤ	kʷɤ
k'	k'ɤ	
ŋ	ŋɤ	
x	xɤ	xʷɤ
0	ɤ	

[shaded] systematic gaps

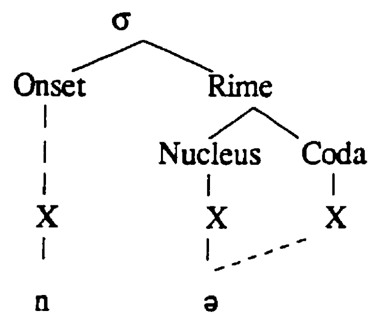
In the distribution shown in (32), /ə/ surfaces as [ɤ], a mid back unrounded vowel. Recall that in section 2.2.1 of Chapter 2 I mentioned that in Mandarin the rime must be bimoraic on the surface, i.e., two and exactly two timing slots. That is to say, if both the nucleus and the coda positions are occupied on the surface, the syllable is licit. However, if the nucleus is occupied while the coda is empty, the syllable is not licit and lengthening occurs as a repair strategy. See Wu 1994 on this as well. I assume that [ɤ] is the lengthened counterpart of [ə]. Thus /ə/ surfaces as [ɤ] in an open syllable. More specifically, when /ə/ occurs in an open syllable, the coda position is empty. Thus /ə/ is lengthened to [ɤ] so as to occupy both the nucleus and the coda slots. I show below the relevant process.

(33) How /ə/ is realized as [ɤ] on the surface

(a) /nə/ after syllabification



(b) /ə/ spreads to take both the nucleus and the coda



(c) Surface form: [nɤ] ("hot")

Thus, what is said to be a mid back unrounded vowel is better thought of as a long mid central vowel.

I mentioned in section 2.2.1 of Chapter 2 that the surface bimoraicity requirement of the rime only applies to a regular or non-neutral-tone syllable. The requirement does not hold for a neutral-tone syllable. A neutral-tone syllable is much shorter in time than a regular-tone syllable. I assume that this can be captured representationally if the rime is not filled with two timing slots. When /ə/ occurs in an open syllable with a neutral tone, it is not lengthened to [ɤ], as happens with a regular tone. Rather, /ə/ is realized as [ə], a single timing unit. I provide some data from Chen and Li 1996. The "phrases" in the first column below are given in the *Pinyin* form (spelling system in China). The underlined syllables have a neutral tone and are an open syllable with /ə/ in the nucleus. The transcription in the second column shows the pronunciation of the syllable under study (underlined).

	Phrases	Transcription	Phrase gloss
(34a)	hu-le	[xu][nə]	"burn-aspect"
(b)	tu-le	[t'əw][nə]	"throw-aspect"
(c)	kun-zhe	[k'ʷən][tsə]	"tie-aspect"
(d)	shuan-zhe	[sʷan][tsə]	"knot-aspect"
(e)	kan-de-qi	[k'an][tə][tɕ'i]	"think-clitic-highly-of"
(f)	ren-de	[rən][tə]	"recognize-clitic"

As can be seen, when /ə/ appears in an open syllable with a neutral tone, it is realized as [ə], without lengthening. Thus we see the following scenario. When /ə/ occurs in an open syllable, how it surfaces depends on the tone. With a regular tone, it is lengthened to [ɤ] because of the surface requirement of two timing slots in the rime. With a neutral tone, it surfaces simply as [ə] because the two-timing-slot condition is not required for a neutral tone syllable. In this way, for the specific environment of "schwa in open syllable", which is based on the criterion of syllable position, there is a further complementary pattern, which is based on the criterion of tone. In (35) I show the distribution.

(35a) /ə/ surfaces as [ɤ] in a regular tone

	/ə/	/ʷə/
p	pɤ	
p'	p'ɤ	
m	mɤ	
f		
t	tɤ	
t'	t'ɤ	
n	nɤ	
ʦ	ʦɤ	
ts'	ts'ɤ	
s	sɤ	sʷɤ
r		
k	kɤ	kʷɤ
k'	k'ɤ	
ŋ	ŋɤ	
x	xɤ	xʷɤ
0	ɤ	

(b) /ə/ surfaces as [ə] in a neutral tone

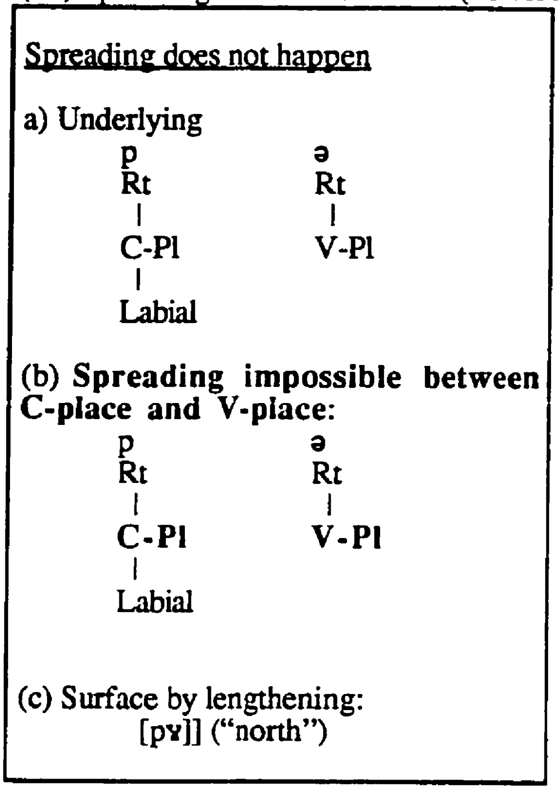
	/ə/
p	
p'	
m	
f	
t	tə
t'	
n	nə
ʦ	ʦə
ts'	
s	
r	
k	
k'	
ŋ	
x	
0	

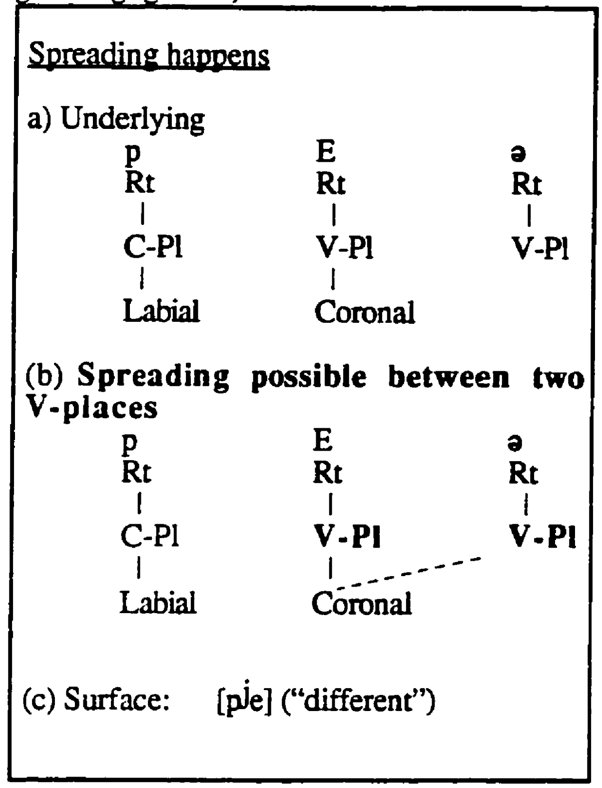
[shaded box] systematic gaps

Notice the data in (35b) are very limited. These are all the neutral-tone syllables I found throughout the elicited lexical items in Chen and Lin 1996.

Having explained the complementary distribution of /ə/ in open syllables, I want to address two points regarding the distribution of /ə/ in (32). First, the mid vowel /ə/ does not assimilate to a preceding consonant (compare with the high vowel /ɨ/). In the environment /Cə/, /ə/ surfaces simply through lengthening (without assimilating to /C/). This has to do with a structural constraint on assimilation for the mid vowel /ə/ in Wuhan, as shown below. Compare when spreading occurs and when it does not with /ə/ as target.

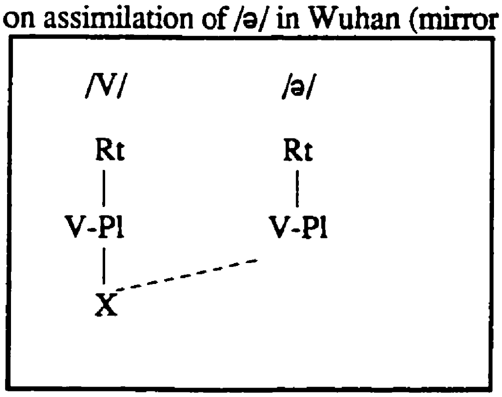
(36) Spreading: C to V vs. V to V (vowel lengthening ignored)





From the comparison above we see that in order for spreading to /ə/ to occur, the nodes immediately above the spreading node play a role. They have to be identical. That is, if Coronal or Labial is the spreading node, it will spread between two V-places, not between a C-place and a V-place (see boldface node above). I illustrate this idea with the structure below.

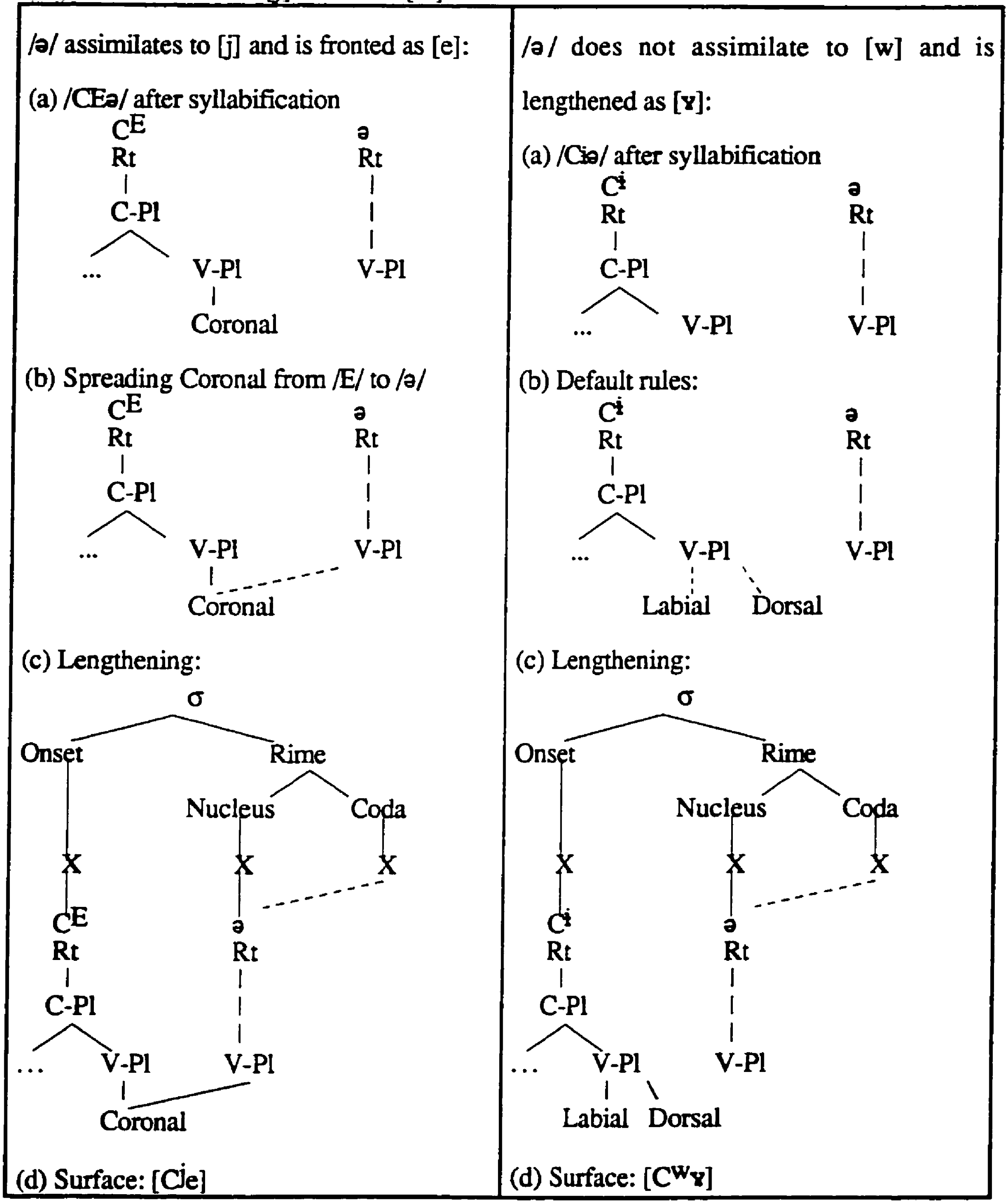
(37) Structural constraint on assimilation of /ə/ in Wuhan (mirror image)



That is, /ə/ only assimilates to a V-place, not a C-place. This structural constraint on /ə/ assimilation holds for all other Mandarin languages under study and will be further seen as the thesis is developed (see also Wu 1994). Further, I assume that this constraint is Mandarin-language-particular and can be understood in the way that /ə/, as a vowel, prefers to assimilate to another vowel in Mandarin. I assume that we should be able to find languages in which /ə/ assimilates to both vowels and consonants, but not to consonants only without vowels.

The second point I want to address regarding the distribution in table (32) is that when /ə/ is preceded by [w], i.e., [C^{w}ə], it does not assimilate to the place of [w]. We can compare this with a parallel case /CEə/, where /ə/ assimilates to the place of /E/. I show this in (38).

(38) /ə/ assimilates to [j] but not to [w] in Wuhan:



I argue that this patterning shows that the vowel [j] carries a place feature Coronal underlyingly for /ə/ to assimilate to. On the contrary, the place feature Labial on the vowel [w] must be absent underlyingly so that /ə/ has nothing to assimilate to. It surfaces through lengthening to [ɤ] instead, whereas [o] would be expected if assimilation to the secondary articulation occurred. This difference between [w] and [j] in their ability to affect /ə/ supports the place specifications proposed for the two vowels: [j] is Coronal while [w] is underlyingly unmarked for place.

The last surface variant of /ə/ is [ə]. If /ə/ is not preceded or followed by [j], and if /ə/ does not occur in an open syllable, it surfaces as [ə]. The distribution is below.

(39) Where /ə/ surfaces as [ə]

	/əɨ/	/ən/	/^{E}ən/	/^{E}əɨ/	/^{V}ən/
p		pən	p^{j}ən		(gap)
p'		p'ən	p^{j}'ən		(gap)
m	məw	mən	m^{j}ən	m^{j}əw	(gap)
f	fəw	fən			(gap)
t	təw	tən	t^{j}ən	t^{j}əw	
t'	t'əw	t'ən	t^{j}'ən		
n	nəw	nən	n^{j}ən	n^{j}əw	
ʦ	ʦəw	ʦən	(gap)	(gap)	
ts'	ts'əw	ts'ən	(gap)	(gap)	
s	səw	sən	(gap)	(gap)	
r			(gap)	(gap)	
k	kəw	kən	ʨən	ʨəw	k^{w}ən
k'	k'əw	k'ən	ʨ'ən	ʨ'əw	k^{w}'ən
ŋ	ŋəw	ŋən			
x	xəw	xən	ɕən	ɕəw	x^{w}ən
0			jən	jəw	vən

(gap) = systematic gaps

I comment on the four environments above separately. First in /Cəɨ/, /ə/ does not assimilate to /ɨ/, since /ɨ/ is without a place feature, and since the requirement on Mandarin syllable structure is satisfied in that both the nuclear and the coda positions are taken, /ə/ surfaces as [ə]. A parallel case to this is /CəE/. As I have mentioned, /CəE/ surfaces as [Cej], with /ə/ assimilating to /E/ and no lengthening. This again confirms the proposed place specifications of the two segments /E/ and /ɨ/. /E/ carries the place feature Coronal underlyingly while /ɨ/ lacks place underlyingly. /ɨ/ surfaces as [w] through default.

Second, /Cən/ surfaces as [Cən]. No assimilation happens since /ə/ only assimilates to a vowel.

Third, /C^Eən/ and /C^Eəɨ/ surface as [C^jən] and [C^jəw], with nothing affecting /ə/. One might ask why /ə/ does not assimilate to the preceding /E/ in this case, as happens in a similar syllable [C^je] discussed earlier (see (30)). I argue that this can be explained by the following constraint on the domain of spreading in Wuhan, and in Mandarin languages in general, as shall be further seen.

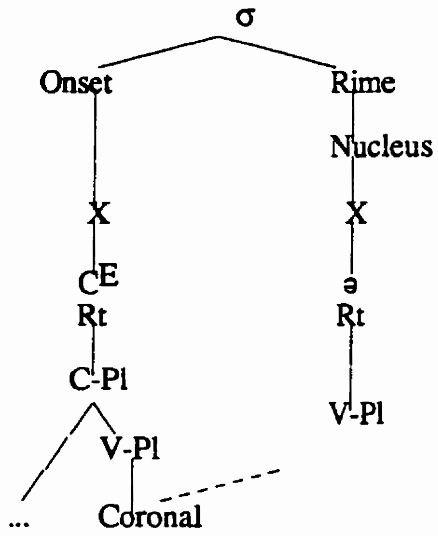
(40) Constraint on domain of spreading in Wuhan

The target c-commands the trigger in syllable structure.

That is, spreading takes place only when the target segment c-commands, in syllable structure, the trigger segment. "C-command" is defined as follows: a node α c-commands a node β if every maximal projection dominating α also dominates β , and α does not itself dominate β (Cowper 1992: 85).

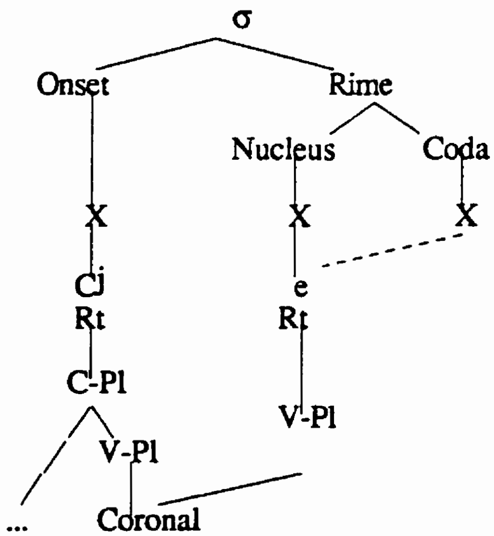
I take a few examples to illustrate how this constraint works. First let us look at [C^je]. The underlying form is /C^Eə/. In this case /ə/ assimilates to /E/.

(41) /ə/ c-commands /E/ in spreading



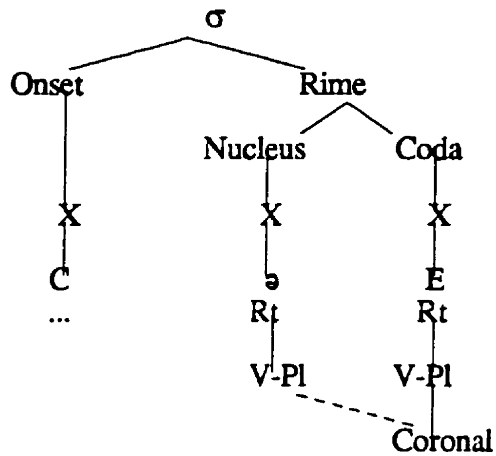
In the structure above, the target /ə/ c-commands the trigger /E/. /E/ spreads its feature Coronal onto /ə/, resulting in [e]. Next the [e] is lengthened to take both slots of the rime to meet the surface bimoraicity requirement of Mandarin syllable structure, as shown below.

(42) /E/ is lengthened on the surface to take both slots of the rime



The second example to illustrate the domain constraint is [Cej]. The underlying form is /CəE/. In this case /ə/ assimilates to the following glide.

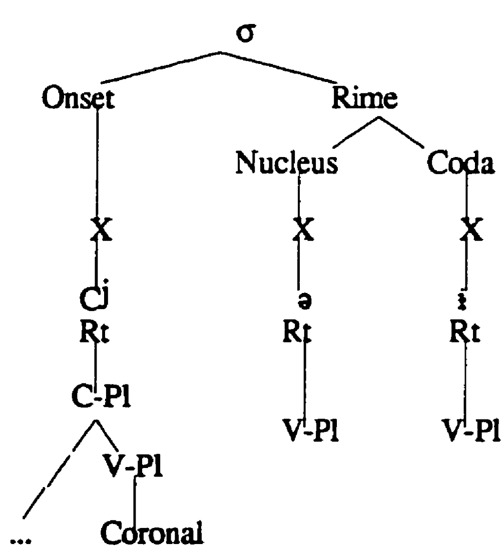
(43) /ə/ c-commands /E/ in spreading



In the above structure the target /ə/ c-commands the trigger /E/. Thus /ə/ assimilates in place to /E/.

The next example is one of the two cases raised as questions above, i.e., [Cʲəw]. The underlying form is /C^{E}əɨ/. I mentioned that no assimilation happens (in 39). Following is the structure.

(44) /ə/ c-commands /ɨ/, not /E/



In the above structure, /ə/ c-commands /ɨ/, not /E/. Thus /ɨ/ is the potential trigger of spreading. However, /ɨ/ is not specified with any place feature to spread to /ə/. /E/ is not available as a trigger because it is not in the appropriate relationship with /ə/. Thus no assimilation happens in this case, and /ə/ surfaces as [ə].

The final sequence [C^{j}ən], in which no assimilation happens either, can be explained in a similar way. That is, /ə/ c-commands /n/, not /E/. Thus /n/ is the potential trigger of spreading. However, since in Wuhan /ə/ only assimilates to vowels and not to consonants, no assimilation occurs.

Thus in both sequences /C^{E}ən/ and /C^{E}əɨ/, /ə/ does not assimilate to the preceding /E/ since /ə/ does not c-command /E/.

Returning to the comments on table (42), the sequence /$C^{ɨ}$ən/ surfaces as [C^{w}ən]. /ə/ c-commands /n/ and so /n/ is the potential trigger of spreading. However, /ə/ does not assimilate to a consonant in Wuhan. Hence no assimilation in this case.

To summarize the mid vowel /ə/, this vowel assimilates in place to an adjacent glide /E/ which it c-commands and surfaces as [e]. It also surfaces as [ɤ], driven by the Mandarin surface syllable structure requirement. In environments other than these, it surfaces as [ə].

3.1.3.4 /O/--> [o]

The second mid vowel is /O/. This vowel is straightforward: it simply surfaces as [o]. I show the distribution.

(45) Distribution of [o]

	/O/	/Oŋ/	/ᴱO/	/ᴱOŋ/
p	po	poŋ		
p'	p'o	p'oŋ		
m	mo	moŋ		
f		foŋ		
t	to	toŋ		tʲoŋ
t'	t'o	t'oŋ		
n	no	noŋ	nʲo	
ʦ	ʦo	ʦoŋ		
ts'	ts'o	ts'oŋ		
s	so	soŋ		
r				
k	ko	koŋ	ʨo	ʨoŋ
k'	k'o	k'oŋ	ʨ'o	ʨ'oŋ
ŋ	ŋo	ŋoŋ		
x	xo	xoŋ	ɕo	ɕoŋ
0	o		jo	joŋ

[shaded box] systematic gaps of *[Dentalʲ]

3.1.3.5 /a/--> [a]

The last vowel is the low vowel /a/. Like /O/, /a/ also surfaces straightforwardly as [a]. I give the distribution below.

(46) Distribution of [a]

	/a/	/aE/	/aɨ/	/an/	/aŋ/	/^{E}a/	/^{E}aɨ/	/^{E}aŋ/	/^{ɨ}a/	/^{ɨ}aE/	/^{ɨ}an/	/^{ɨ}aŋ/
p	pa	paj	paw	pan	paŋ	p^{j}a	p^{j}aw	p^{j}aŋ				
p'	p'a	p'aj	p'aw	p'an	p'aŋ	p^{j}'a	p^{j}'aw	p^{j}'aŋ				
m	ma	maj	maw	man	maŋ		m^{j}aw					
f	fa			fan	faŋ							
t	ta	taj	taw	tan	taŋ	t^{j}a	t^{j}aw	t^{j}aŋ				
t'	t'a	t'aj	t'aw	t'an	t'aŋ	t^{j}'a	t^{j}'aw	t^{j}'aŋ				
n	na	naj	naw	nan	naŋ	n^{j}a	n^{j}aw	n^{j}aŋ				
ts	tsa	tsaj	tsaw	tsan	tsaŋ				ts^{w}a	ts^{w}aj	ts^{w}an	ts^{w}aŋ
ts'	ts'a	ts'aj	ts'aw	ts'an	ts'aŋ				ts^{w}'a	ts^{w}'aj	ts^{w}'an	ts^{w}'aŋ
s	sa	saj	saw	san	saŋ				s^{w}a	s^{w}aj	s^{w}an	s^{w}aŋ
r									r^{w}a	r^{w}aj		
k	ka	kaj	kaw	kan	kaŋ	tɕa	tɕaw	tɕaŋ	k^{w}a	k^{w}aj	k^{w}an	k^{w}aŋ
k'	k'a	k'aj	k'aw	k'an	k'aŋ	tɕ'a	tɕ'aw	tɕ'aŋ	k^{w}'a	k^{w}'aj	k^{w}'an	k^{w}'aŋ
ŋ	ŋa	ŋaj	ŋaw	ŋan	ŋaŋ	ŋa						
x	xa	xaj	xaw	xan	xaŋ	ɕa	ɕaw	ɕaŋ	x^{w}a	x^{w}aj	x^{w}an	x^{w}aŋ
0	a					ja	jaw	jaŋ	wa	waj	wan	waŋ

systematic gaps of *[Labial^{W}]

/a/ is also a central vowel. Unlike the other two central vowels in this language, /ɨ/ and /ə/, which assimilate in place to another segment, /a/ does not assimilate. The same is found with the other Mandarin languages under study. I will summarize the assimilation patterns of the three central vowels for Mandarin languages in section 4.3 of Chapter 4.

To summarize the place features of the five vowels, I have provided evidence to show that the place feature Coronal on [i] is active whereas the place feature Labial on [u] is inert in the phonology, and thus Coronal is underlyingly present on [i] (/E/) but Labial is underlyingly absent on [u] (/ɨ/). Further Labial is underlyingly present on [o]. Next I examine the height specifications of the five vowels.

3.1.4 Height specifications

In the discussions of place features I have simply assumed, for convenience, the phonological height of each vowel being identical with its surface height. Below I repeat the feature specifications of the five vowels in a shorthand way.

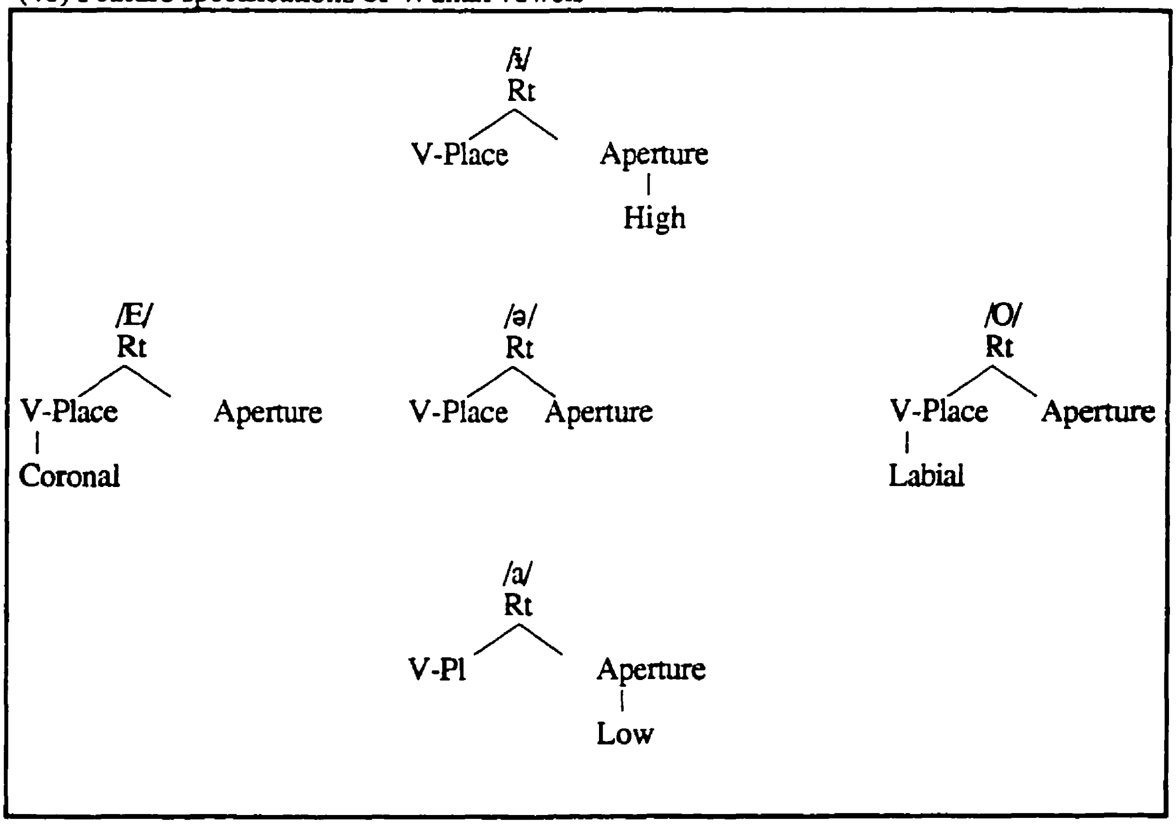
(47) Feature specifications of the five vowels in Wuhan

	ɨ	
E	ə	O
	a	

There are three central vowels in the system. I have already justified why /ɨ/ and /ə/ are unspecified for place, and I assume that /a/ too is unspecified for place. Thus there is a three-way height contrast among central vowels. Assuming that Low and High are the relevant features, /a/ must be specified with Low and /ɨ/ has to be specified with High. For these three vowels, there is no other choice regarding height specification. The question is the other two vowels, the front vowel, specified with place feature Coronal, and the back vowel, specified with place feature Labial. I have already justified why the two vowels are specified with their respective place feature. We see that unlike central vowels, which create a three-way height contrast, both the front vowel and the back vowel create only a one-way height contrast within their place of articulation in the system. In other words the front vowel does not contrast with another front vowel in terms of height and the back vowel does not contrast with another back vowel in terms of height.

Following the assumptions about feature specifications laid out in section 2.1.1 of Chapter 2, I assume that features are necessary either for contrasts in the system or for activeness in the phonology. Given that the front vowel in Wuhan does not contrast in terms of height with another front vowel, and that the back vowel does not contrast in terms of height with another back vowel (also that height features are not active in the phonology), I propose that the two vowels are unspecified for height. This means the two vowels are phonological mid vowels. I give the feature specifications of the five vowels below, with both place and height features.

(48) Feature specifications of Wuhan vowels



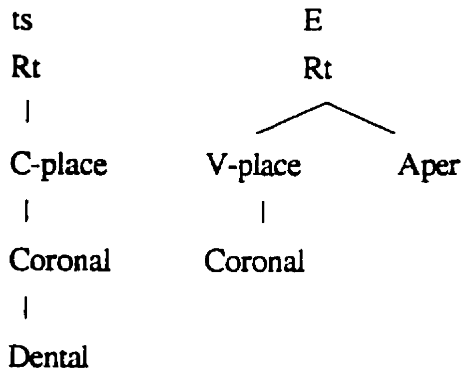
Now I show how the vowels are realized on the surface in terms of height. In particular, since the front vowel /E/ and the back vowel /O/ are unspecified for height features owing to the lack of contrast, I show how these two vowels surface.

Following the idea of vowel dispersion, i.e., vowels across languages tend to be realized as far apart as possible in the vowel space (see Flemming 1995, among others), I assume that a front vowel or a back vowel tends to surface as high, taking two corners of the vowel triangle. In other words, a front or a back vowel, without being specified for a height feature, will surface as a high vowel through a default rule which inserts High. Next I illustrate with examples how the two vowels /E/ and /O/ surface in Wuhan. First I examine /E/.

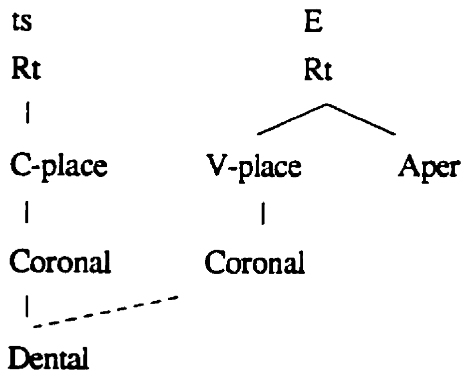
The first example is /tsE/ (surface [tsɿ]), where /E/ appears in an open syllable.

(49) How /E/ surfaces as [ɿ] after a dental consonant (lengthening ignored)

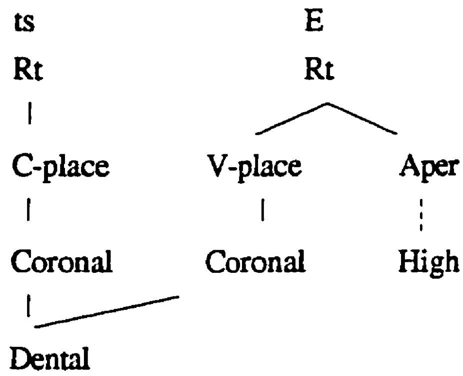
(a) Underlying



(b) Spreading



(c) Default rule of High



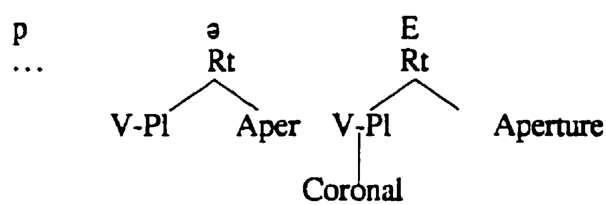
(d) Surface: [tsɿ] ("self")

After spreading in (49b), High is inserted on /E/ in (49c). Hence the surface form [tsɿ].

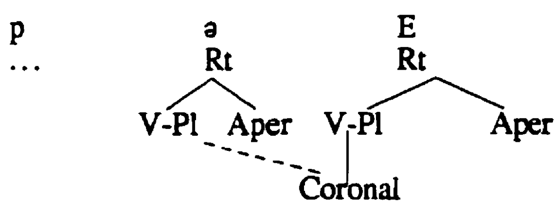
The second example is /pəE/ (surface form [pej]). Here the front vowel /E/ appears in the coda.

(50) How /pəE/ surfaces as [pej] in Wuhan

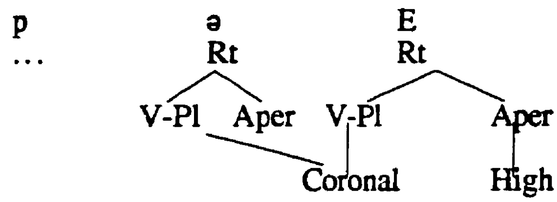
(a) Underlying



(b) Spreading from /E/ to /ə/



(c) Default High on /E/



(d) Surface form: [pej] ("quilt")

In (50b), the place feature Coronal spreads from /E/ to /ə/, as discussed in section 3.1.3.3. At this stage we have two adjacent front vowels. Next the feature High is inserted on /E/ by default, shown in (50c). A question here concerns why High is inserted on one vowel /E/, in the coda, but not on the other /ə/, in the nucleus? I propose that this is because /E/ is in the coda while /ə/ is in the nucleus. In Mandarin the coda position requires either a glide or a consonant (see chapter 2 section 2.2.1). Thus /E/ has to surface as a high vowel to meet this requirement. Hence default High on /E/ in the coda. Once the segment in the coda is realized as a high vowel, the vowel in the nucleus cannot be realized as a high vowel. If High is also inserted on the nuclear vowel /ə/, we would have a surface result of *[pij]. However, if one examines the possible surface vowel sequences in Wuhan, a generalization concerning height is found: with the exception of the long vowels derived from lengthening, no sequences of high vowels exist. I treat this as a constraint in the language and express it as follows.[15]

(51) Constraint on vowel-vowel sequence in Mandarin: $*_{\sigma}[\text{high-high}]_{\sigma}$

Thus High is only inserted on /E/, which is in the coda, but not on /ə/, which is in the nucleus. Hence [pej]. In other words, the default rule inserting High refers to the syllable

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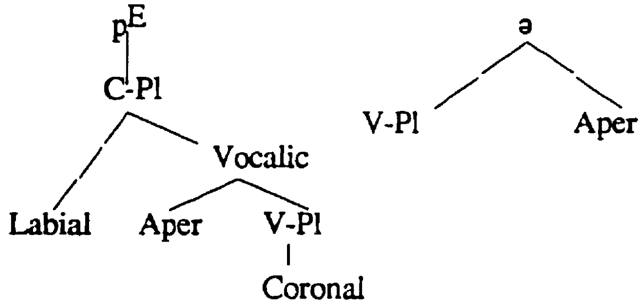
[15] I will also discuss this surface constraint when I discuss the status of [ü] in section 3.1.5.

position, when there is more than one potential targets of the rule. Default insertion of High on the coda bleeds insertion of High on the nucleus. In the absence of a vowel in the onset or coda, default High is inserted on the nucleus, as in (49).

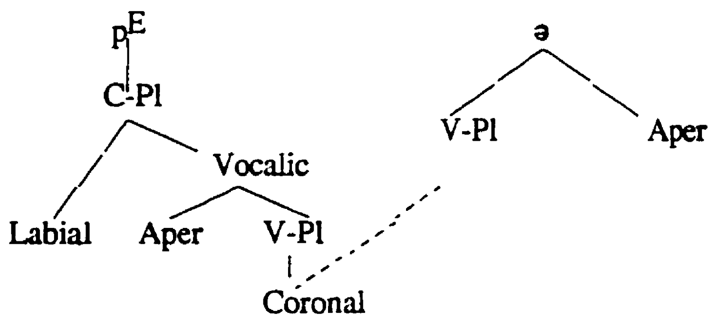
The third example is /pEə/ (surface form [p^{j}e]). Here the front vowel /E/ appears in the onset position.

(52) How /pEə/ surfaces as [p^{j}e] in Wuhan (syllable structure ignored)

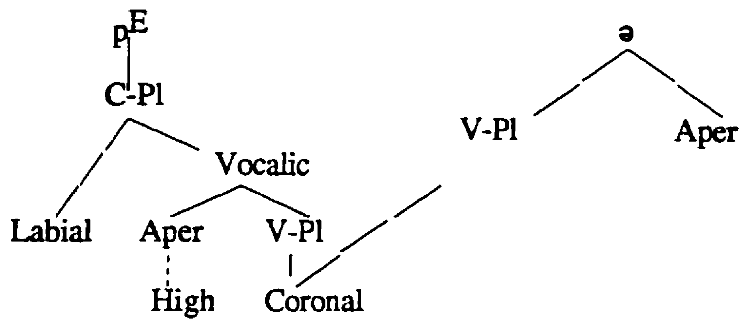
(a) Structure of /pEə/ after syllabification



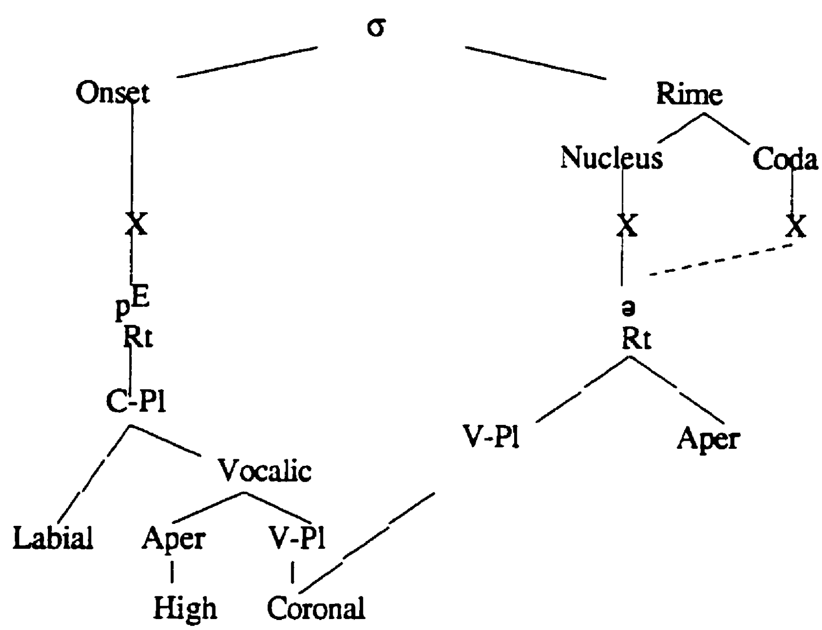
(b) Spreading of Coronal from /E/ to /ə/



(c) Default High on /E/



(d) Lengthening of /ə/



(e) Surface form: [pje] ("different")

In (52b) the feature Coronal is spread from /E/ onto /ə/. In (52c) High is inserted on /E/ in the onset, but not on /ə/, which is in the nucleus. The reason is similar to that discussed with respect to [pej], in (50). The onset position requires either a consonant or a glide (as secondary articulation). Thus High is inserted on /E/ to ensure that it surfaces as a high vowel. Since /E/ surfaces as high, /ə/ cannot surface as high since two consecutive high vowels in a syllable are not allowed in Mandarin. Thus no default High is inserted on /ə/.

Again, insertion on a non-nucleus bleeds insertion on a nucleus. In (52d) /ə/ is lengthened to occupy both slots of the rime to meet the surface bimoraicity requirement of Mandarin. Hence [pʲe].

Above I have shown how different cases of the front vowel /E/ in Wuhan surface through a default rule which inserts High. Now I discuss the back vowel /O/. The back vowel might also be expected to receive a default High feature, surfacing as [u]. However, in Wuhan the default rule does not apply to the back vowel /O/; it simply surfaces as [o]. Recall that I have discussed that the other vowel /ɨ/ surfaces as [u]. This means if /O/ receives a default feature High and also surfaces as [u], the two phonemes would be neutralized on the surface. I propose that in Wuhan having different phonemes surface as distinct forms is important so that the default rule of High can be saved in order to avoid surface neutralization of two phonemes (see Dyck 1995 and Avery 1996). In Chapter 4 I will show that when neutralization is not an issue, as in the Mandarin language Chengde, default High applies to the back vowel.

To summarize the discussion of height features in Wuhan, for central vowels there is a three-way contrast in the system and two height features are used to capture the contrast. For the other two vowels, the front vowel and the back vowel, since there is no height contrast and no phonology forces their presence in the system, they are unspecified for height. Further, the front vowel surfaces through a default rule of High. The back vowel cannot surface as high because the result, [u], would cause surface neutralization of two phonemes, which is not allowed in the language. The back vowel thus surfaces as [o].

Having discussed the place and height features of the vowels in Wuhan, I give a summary of the realizations of different vowel-vowel sequences in Wuhan.

(53) Summary of the realizations of different vowel-vowel sequences in Wuhan

Phonological: V_1V_2	Phonetic	Source
Eə	j[e]	assimilation of /ə/; default High on /E/ (see 52 for derivation)
Ea	j[a]	default High on /E/
EE	does not surface (1)	
EO	j[o]	default High on /E/[16]
ɨɨ	does not surface (1)	
ɨə	w[ɤ]	default Labial on /ɨ/; lengthening of /ə/
ɨa	w[a]	default Labial on /ɨ/
ɨO	w[o]	default Labial on /ɨ/ or assimilation of /ɨ/
əɨ	[ə]w	default Labial on /ɨ/
əə	does not surface (1)	
əa	does not surface (2)	
əE	[e]j	assimilation of /ə/; default High on /E/ (see 50 for derivation)
əO	does not surface (2)	
aɨ	[a]w	default Labial on /ɨ/
aə	does not surface (2)	
aa	does not surface (1)	
aE	[a]j	default High on /E/
aO	does not surface (2)	
Oɨ	[o]w	default Labial on /ɨ/ or assimilation of /ɨ/ (see 28 for derivation)
Oə	does not surface (2)	
Oa	does not surface (2)	
OE	*oj (accidental gap)	
OO	does not surface (1)	
Eɨ	ü	default High on /E/; default Labial on /ɨ/; coalescence of /E/ and /ɨ/ (see section 3.1.5)
ɨE	ü	default Labial on /ɨ/; default High on /E/ (see section 3.1.5)

Note: [] around the vowel in the nucleus.

In the above table, the first column gives all the logical possibilities of the underlying two-vowel sequences in Wuhan. The second column shows the surface forms of each sequence. The third column gives the derivational processes from the underlying to the surface forms. Notice I have shown that the two sequences /eɨ/ and /ɨe/ surface as [ü]. I address this issue in the following section 3.1.5.

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[16]See section 2.2.1 of Chapter 2 for the syllabification of /EO/.

There are some sequences which do not surface in the above table. I use numbers (1 or 2) to indicate the type of reasons for these gaps. First, the fact that sequences /ɨɨ/, /əə/, /aa/, /EE/, and /OO/ do not surface can be explained by a constraint in Wuhan which does not allow two identical vowel sequences, as expressed below.

(54) Constraint against identical vowel sequences: $*_{\sigma}/V_1\text{-}V_1/_{\sigma}$

This constraint holds for the other Mandarin languages under study. Notice this constraint only rules out two UNDERLYING identical vowels. Thus, it is fine when an underlying vowel is lengthened on the surface, resulting in two SURFACE identical vowels, but vowels which share all features.

The reason that the second type of sequences do not surface is that the vowel syllabified as the non-nucleus cannot surface as a high vowel or glide, which is requirement for the non-nuclear position in Mandarin. For instance, in the sequence /əa/, /ə/ is syllabified as the onset (/a/ as the nucleus since it is lower than /ə/). However, /ə/ does not have a corresponding glide, unlike /E/, the corresponding glide of which is [j].

3.1.5 The vowel [ü]

Having discussed both place and height features of the five vowels, I address one surface vowel which has been left untouched so far, [ü]. Unlike the other surface vowels in this language which are derived from a single source (i.e., each surface vowel has only one underlying form), I propose that [ü] is derived from two vowels, [i] and [u] (underlyingly /E/ and /ɨ/ respectively), and is a coalesced form of the two vowels. The distribution of [ü] is very limited, as presented below.

(55) Distribution of [ü]

[ü] in Nucleus

	ü
p	
p'	
m	
f	
t	
t'	
n	nü
ʦ	
ts'	
ʂ	
r	
k	ʨü
k'	ʨ'ü
ŋ	
x	ɕü
0	ü

[ü] in Onset

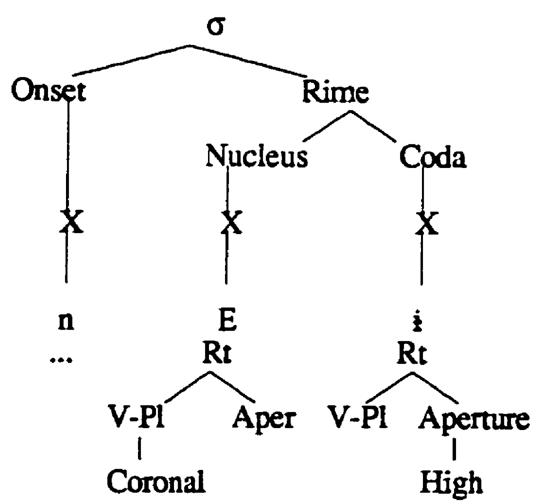
	ɥe	ɥən
p	░	░
p'	░	░
m	░	░
f	░	░
t		
t'		
n		
ʦ	░	░
ts'	░	░
ʂ	░	░
r	░	░
k	ʨʷe	
k'	ʨʷ'e	
ŋ		
x	ɕʷe	
0	ɥe	ɥən

░ systematic gaps

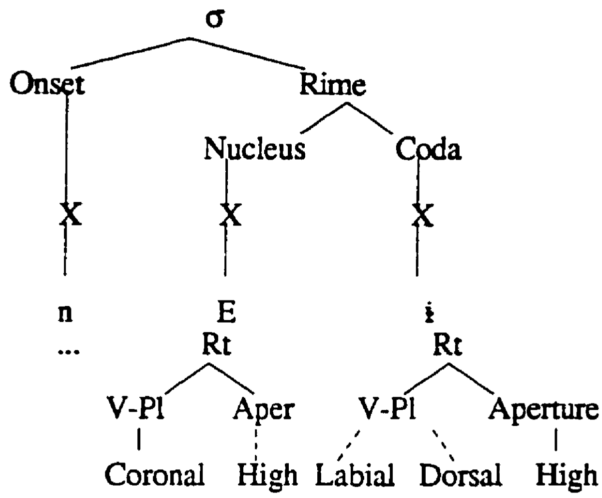
To explain how [ü] is derived when in the nucleus, I take [nü] as an example. I propose that the underlying form is /nEɨ/.

(56) How [nü] is derived from /neɨ/ in Wuhan

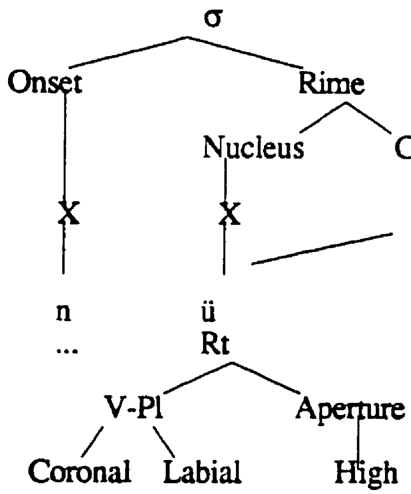
(a) Structure after syllabification: /E/ syllabified in the nucleus and /ɨ/ in the coda



(b) Default rule of High on /E/ and Labial plus Dorsal on /ɨ/



(c) Coalescence of /E/ and /ɨ/



(d) Surface: [nü] ("woman")

In (56a) /E/ is syllabified in the nucleus since it is lower in height than the other vowel /ɨ/. In (56b) the default rule inserting High applies to /E/ and the default rules adding Labial and Dorsal apply to /ɨ/, as discussed earlier this section. At this point we have two high vowels [i-u]. Recall that two surface high vowels are not allowed in Wuhan (see 51). To solve this problem, the two vowels [i] and [u] are merged. The result is [ü], with the Coronal feature of [i] and Labial feature of [u], as in (56c). Hence [nü].

Here I compare (56b) with (52c). In (52c) the default rule which inserts High applies to /E/, which is syllabified in the onset. The default rule inserting High cannot apply to /ə/, which is syllabified in the nucleus. I pointed out that this is because the vowel in the onset has to be a high vowel or glide in Mandarin, and further a two-high-vowel sequence is not allowed in Mandarin. In (56b), the default rule inserting High applies to /E/, which is syllabified as the nucleus. Notice the vowel in the coda is also a high vowel. This results in a two-high-vowel sequence, which is not allowed in Mandarin. Hence coalescence. Now the question is: why in (56b) can the default rule High apply with the result of two surface high vowels (with further coalescence), while in (52c) the default rule High cannot apply because of the constraint of two surface high vowels? In other words, how do we know that the default rule inserting High applies to the nuclear vowel in one case (/E/; 56b) but not the other (/ə/; 52c)? I propose the following constraint on the application of the default rule High:

(57) Constraint on the application of the default rule High:

> The default rule inserting High applies to a nuclear vowel only if it is singly linked with a place feature.

Thus in (56b) the nuclear vowel /E/ is singly linked with the place feature Coronal; the default rule of High applies to the vowel. In (52c) the place feature Coronal is doubly linked to both /ə/ and /E/. Thus the default rule does not apply to the nuclear vowel /ə/.[17]

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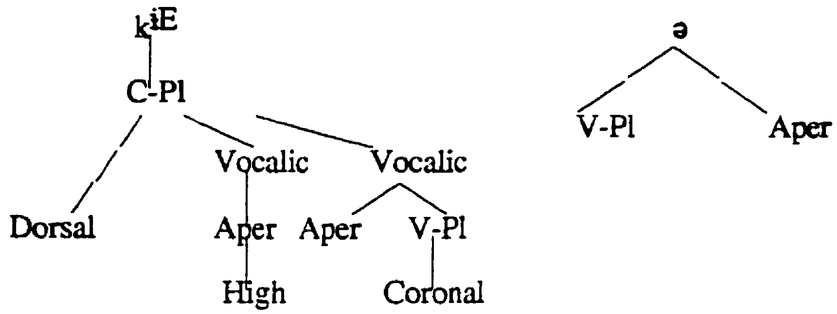
[17]Recall that in (49) the default rule inserting High also applies to the nuclear vowel /E/ in the sequence /tsE/. /E/ is singly linked with the place feature Coronal.

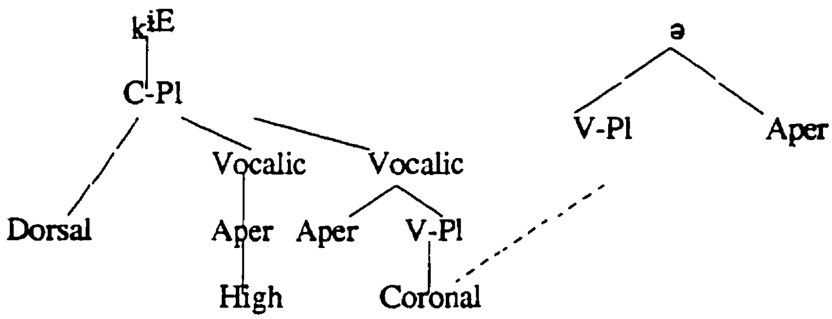
In table (55), we see that [ü] also appears in the onset. I take [tɕʷe] as an example and explain how [ü] is derived when in the onset. The underlying form of [tɕʷe] is /k^{ie}ə/.[18]

(58) How [tɕʷe] is derived from /k^{iE}ə/ in Wuhan

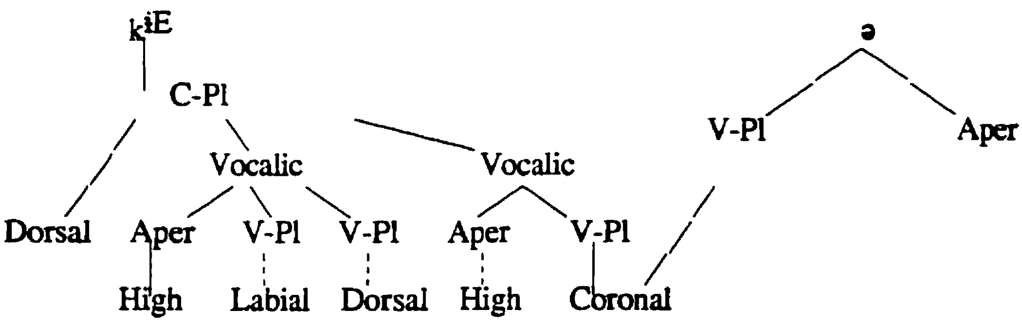
(a) After syllabification



(b) Spreading from /E/ to /ə/



(c) Default rule of Labial and Dorsal on /i/ and default rule of High on /E/



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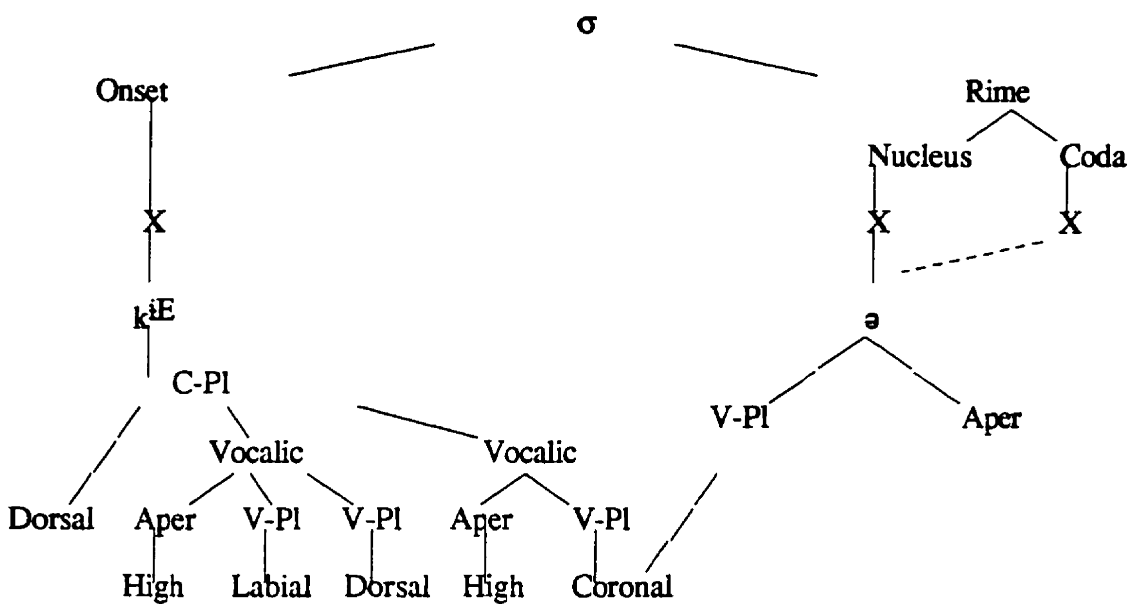
[18]The ordering of /ie/ is flexible.

(d) Lengthening of /E/



(e) Palatalization of /k/ and surface form : [ʨʷe] ("lack")

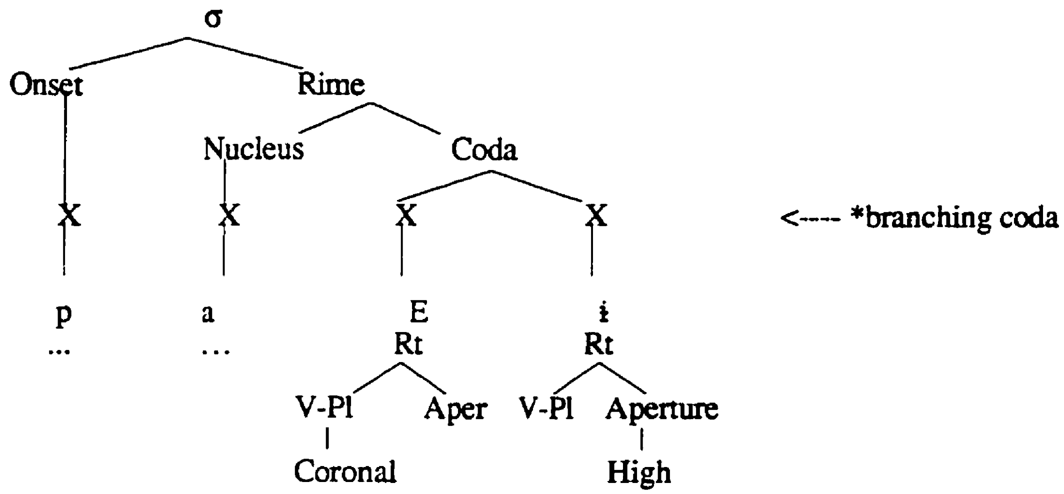
In (58b) spreading takes place from /E/ to /ə/. In (58c) default rules inserting Labial and Dorsal apply to /ɨ/ and the default rule inserting High applies to /E/. In (58d) /E/ is lengthened to meet the surface syllable structure requirement. Finally after /k/ is palatalized, i.e., /k^{E}/ realized as [ʨ], /k^{ie}ə/ surfaces as [ʨʷe]. Notice in this case the palatalization of /k/ blocks (by taking place first) the application of coalescence of /ɨ/ and /E/ (which otherwise would surface as [ü]). In section 4.2.1 of Chapter 4 I will present a case in which coalescence does happen in the onset.

In table (55) we see that while [ü] appears in the onset (and the nucleus as well), it never appears in the coda. Recall that the other two vowels which appear as secondary articulation, i.e., /E/ ([j] on the surface) and /ɨ/ ([w] on the surface), can also occur in the coda. I argue that this special distribution of [ü] supports the bisegmental status of this vowel. Next I explain why [ü] appears in the onset but not in the coda.

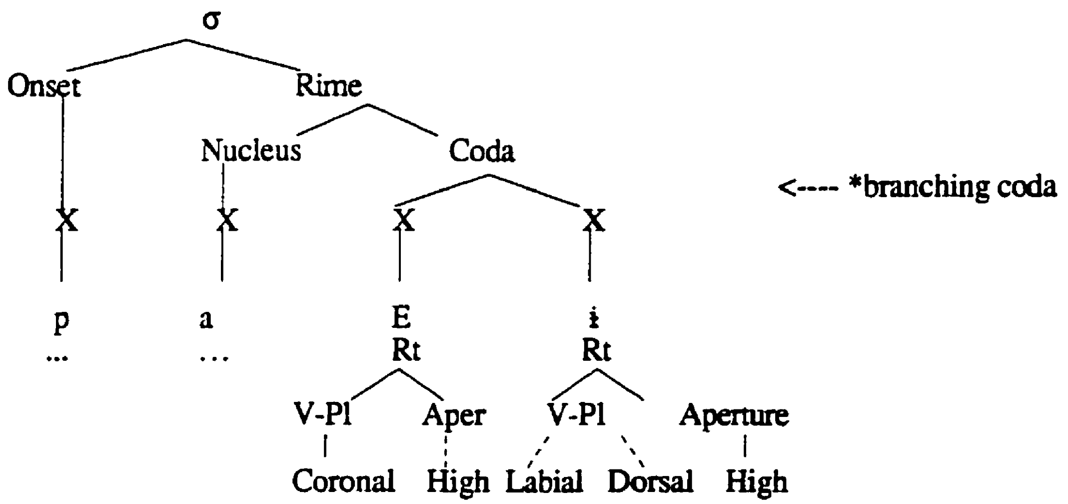
First I show why [ü] is not found in the coda. I take a hypothetical example [paü] to illustrate. The underlying form of [paü] is /paeɨ/. Following is the derivational process.

(59) How [paü] would be derived from /paEɨ/

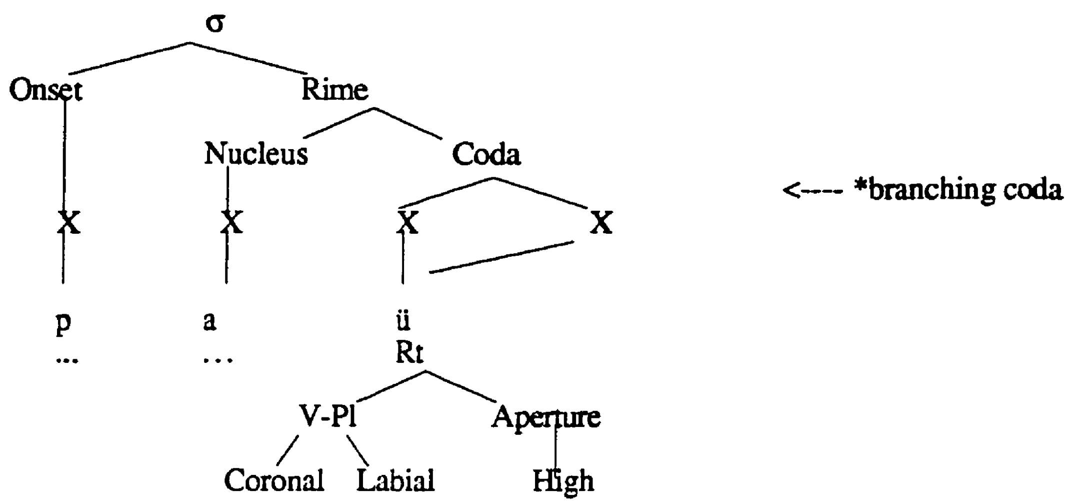
(a) Underlying



(b) Default rule of High on /E/ and Labial plus Dorsal on /ɨ/



(c) Coalescence of /E/ and /i̶/

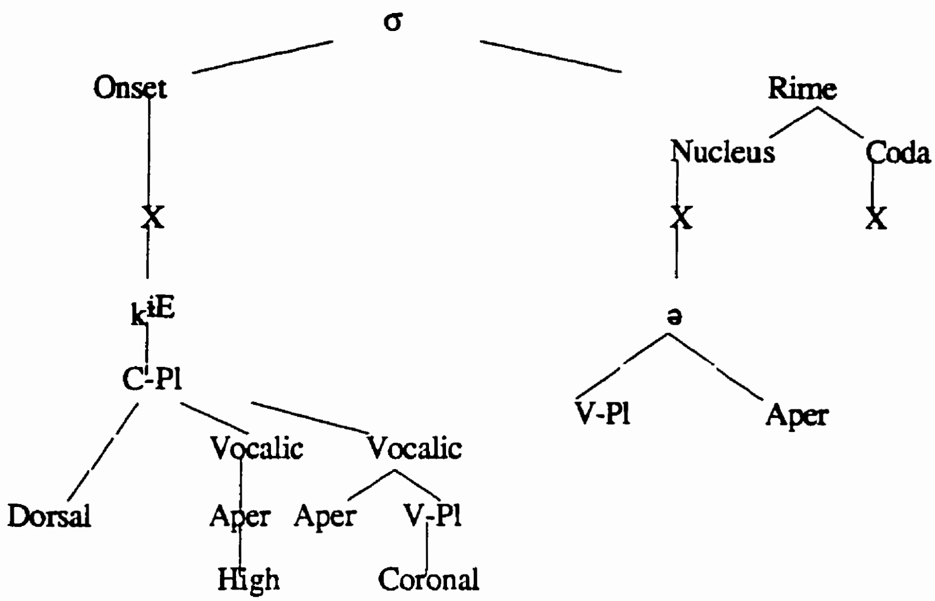


(d) Surface: [paü] (hypothetical word)

In (59a) we see that both /E/ and /i̶/ are syllabified in the coda. Thus we have a branching coda. I show in section 2.2.1 of Chapter 2 that in Mandarin, each of the three syllable positions, i.e., the nucleus, the onset, and the coda, can only have a single timing slot both underlyingly and on the surface. None of them can branch. Thus the Mandarin syllable structure is violated if /E/ and /i̶/ (the underlying form of [ü]) appear in the coda. In (59b) I show how the default rules would apply to /E/ and /i̶/. In (59c) I show the result of coalescence of /E/ and /i̶/. As we see, if [ü] appears in the coda, we will have a branching coda, which is not allowed by the Mandarin syllable structure requirement. This is the reason that [ü] is never found in the coda position.

On the other hand, [ü] appears in the onset. I have already shown in (58) the derivational process when [ü] occurs in the onset. I repeat (58a), the underlying structure, for illustration.

(60) Underlying structure of [tɕʷe] (/k^{iE}ə/)



As we see, both /E/ and /ɨ/ are syllabified in the onset as secondary articulations on the consonant. /k^{iE}/ takes the one-timing-slot of the onset, required by the Mandarin syllable structure. In other words, it is fine to have two vowels syllabified as secondary articulation of the consonant.

To summarize, I propose that the surface vowel [ü] is derived from two underlying vowels /E/ and /ɨ/. Because of this bisegmental status, [ü] cannot appear in the coda, since a branching coda is not allowed by the Mandarin syllable structure. However, [ü] appears in the onset (and nucleus as well), since two vowels can be both syllabified as secondary articulation of the consonant. I have also shown the derivations of the occurrences of [ü].

3.1.6 Conclusions of Wuhan

In this section I examined how the surface vowels in Wuhan in (3) are derived from the five phonological vowels proposed. I have argued for the place and the height feature specifications of each vowel. Specifically I have pointed to the difference in patterning of surface front and surface back round vowels. In the next section I introduce Linfen, another five-vowel inventory, to compare with Wuhan.

3.2 Linfen

In this section I introduce a second five-vowel inventory, Linfen. Linfen has the same phonological vowel inventory as Wuhan. However, Linfen differs from Wuhan in how the vowel /ɨ/ surfaces. More specifically while /ɨ/ in Wuhan surfaces by both assimilation (in the nuclear position) and default (in the non-nuclear position), it surfaces only by default in Linfen. By comparing the two languages, we will see what is common to Mandarin languages and how they could differ.

3.2.1 Consonants

First, I present the surface consonant inventory of Linfen. The data for this language comes from Li and Chen 1996.

(61) Phonetic consonant inventory of Linfen

		Labial	Alveolar	Dental	Retroflex	Palatal	Velar
Stops and affricates	-asp	p	t	ts	tʂ	tɕ	k
	+asp	p'	t'	ts'	tʂ'	tɕ'	k'
Fricatives		f, v		s	ʂ, ʐ	ɕ	x
Sonorants		m	n, l				ŋ

Notice in Linfen there is voicing contrast for labial fricatives, and a nasal/lateral contrast for alveolar sonorants. Neither contrast is found in Wuhan. These differences do not affect the vowel inventories. Assuming that palatal consonants are not underlying consonants but velar consonants surfacing with palatalization, the phonological consonant inventory of Linfen is as follows.

(62) Phonological consonant inventory of Linfen

		Labial	Alveolar	Dental	Retroflex	Velar
Stops and affricates	-asp	p	t	ts	ʈʂ	k
	+asp	p'	t'	ts'	ʈʂ'	k'
Fricatives		f, v		s	ʂ, ʐ	x
Sonorants		m	n, l			ŋ

The place specifications of the consonants above have been discussed in Chapter 2 and are not repeated.

3.2.2 Vowel inventory: phonetic

Next I examine the vowel inventory. First I introduce the phonetic vowel inventory.

(63) Phonetic vowel inventory of Linfen

	Front		Central	Back	
	Unrounded	Rounded	Unrounded	Unrounded	Rounded
High	i	ü	ɿ	ʅ	u
Mid	e		ə	ɤ	o
Low			a		

This inventory is very similar to the one in Wuhan (see (3)). The only difference is that the apical vowel [ʅ] exists in Linfen but not in Wuhan. I have already explained this as being due to the influence of the retroflex consonants. With the two surface inventories being so much alike, the next question is: are the vowels distributed in the same way in the two languages? We need to see where the distributions are similar and where they differ. In order to do this, I propose first, based on the distributions of the vowels in (64), the phonological vowel inventory of the language.

(64) Proposed phonological vowel inventory of Linfen

	ɨ	
E	ə	O
	a	

Further I propose these vowels surface in the following way.

(65) How vowels surface in Linfen

/E/ -->	[ɿ]	after a dental consonant
	[ʅ]	**after a retroflex consonant**
	[i]	elsewhere
/ɨ/ -->	**[u]**	**by default**
/ə/-->	[e]	following or preceding glide [j]
	[ɤ]	in open syllable but not following glide [j]
	[ə]	elsewhere
/a/-->	[a]	
/O/-->	[o]	

I have bolded some parts. These are places where Linfen differs from Wuhan. Next I need to go through the distribution of each vowel so as to determine the feature specifications of each vowel. I separate place features from height features. First I examine place features, assuming height features as indicated in (64). The place feature specifications I propose for the five vowels are structurally represented as below.

(66) Place feature specifications of the five vowels: structural representations

/E/	/ɨ/, /ə/, /a/	/O/
Rt	Rt	Rt
|	|	|
V-Place	V-Place	V-Pl
|		|
Coronal		Labial

I start with the front vowel /E/.

3.2.3 Place specifications

3.2.3.1 /E/ --> [ı], [ɩ], [i]

The vowel /E/ has three surface forms, [ı], [ɩ], and [i]. The distributions of both [ı] and [ɩ] are very limited, as shown in the two tables in (67) and (68) respectively.

(67) Distribution of [ɿ]

	/E/
p	
p'	
m	
f	
v	
t	
t'	
n	
l	
ts	tsɿ
ts'	ts'ɿ
s	sɿ
tʂ	
tʂ'	
ʂ	
ʐ	
k	
k'	
ŋ	
x	
0	

The vowel [ɿ] is only found *in the nucleus* and *following a dental consonant.*

(68) Distribution of [ʅ]

	/E/
p	
p'	
m	
f	
v	
t	
t'	
n	
l	
ts	
ts'	
s	
tʂ	tʂʅ
tʂ'	tʂ'ʅ
ʂ	ʂʅ
ʐ	ʐʅ
k	
k'	
ŋ	
x	
0	

The vowel [ʅ] is only found *in the nucleus* and *following a retroflex consonant.* Thus [ɿ] and [ʅ] are in complementary distribution with the vowel [i]. Next I present the distribution of [i]. I show the distribution of [i] according to the syllable position it appears in, i.e., in the nucleus, in the coda, and in the onset.

(69) Distribution of [i]

<u>(69a) [i] found in the nucleus</u>

	/E/
p	pi
p'	p'i
m	mi
f	
v	vi
t	ti
t'	t'i
n	ni
l	li
ts	
ts'	
s	
tʂ	
tʂ'	
ʂ	
ʐ	
k	tɕi
k'	tɕ'i
ŋ	
x	ɕi
0	i

(69b) [i] found in the coda

	/aE/	/əE/	/^{E}aE/	/^{w}aE/	/^{w}əE/
p	paj	pej			
p'	p'aj	p'ej			
m	maj	mej			
f	faj	fej			
v					
t	taj	tej			t^{w}ej
t'	t'aj	t'ej			t^{w}'ej
n	naj	nej			
l	laj				
ʦ	ʦaj	ʦej			$ʦ^{w}$ej
ts'	ts'aj	ts'ej			ts^{w}'ej
s	saj	sej			s^{w}ej
ʈʂ	ʈʂaj				$ʈʂ^{w}$ej
tʂ'	tʂ'aj				$tʂ^{w}$'ej
ʂ	ʂaj				$ʂ^{w}$ej
ʐ					
k	kaj		ʨaj	k^{w}aj	k^{w}ej
k'	k'aj			k^{w}'aj	k^{w}'ej
ŋ	ŋaj				
x	xaj		ɕaj	x^{w}aj	x^{w}ej
0				waj	wej

(shaded) systematic gaps

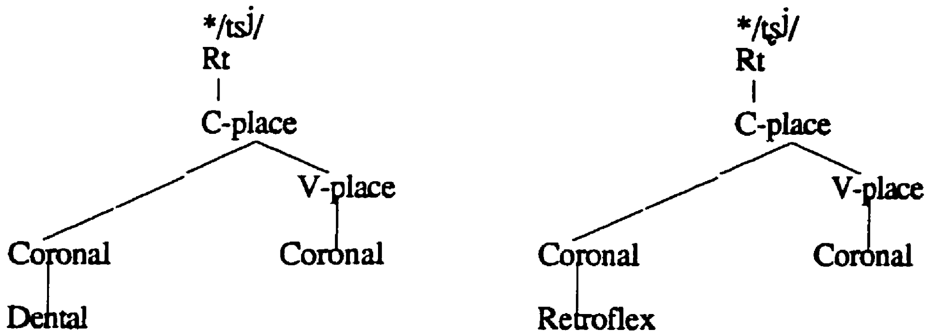
(69c) [i] found in the onset

	/Ea/	/Eə/	/Eən/	/EaE/	/Eai/	/Eəi/	/Ean/	/Eaŋ/
p	pʲa	pʲe	pʲən		pʲaw		pʲan	
p'	pʲ'a	pʲ'e	pʲ'ən		pʲ'aw		pʲ'an	
m	mʲa	mʲe	mʲən		mʲaw		mʲan	
f								
v								
t	tʲa	tʲe			tʲaw	tʲəw	tʲan	
t'	tʲ'a	tʲ'e			tʲ'aw		tʲ'an	
n	nʲa	nʲe	nʲən		nʲaw	nʲəw	nʲan	nʲaŋ
l	lʲa	lʲe	lʲən		lʲaw	lʲəw	lʲan	lʲaŋ
ts								
ts'								
s								
tʂ								
tʂ'								
ʂ								
ʐ								
k	tɕa	tɕe	tɕən	tɕaj	tɕaw	tɕəw	tɕan	tɕaŋ
k'	tɕ'a	tɕ'e	tɕ'ən		tɕ'aw	tɕ'əw	tɕ'an	tɕ'aŋ
ŋ								
x	tɕ'a	ɕe	ɕən	ɕaj	ɕaw	ɕəw	ɕan	ɕaŋ
j	ja	je	jən		jaw	əw	an	jaŋ

(shaded) systematic gaps

When [i] occurs in the nucleus, it follows labials, alveolars, and dorsals, but not dentals or retroflexes. This shows the complementary distribution with the other two vowels [ɿ] and [ʅ]. For this reason I regard [ɿ], [ʅ], and [i] as three surface forms of one phoneme /E/ (the phonological height of this front vowel is addressed in section 3.1.2). Notice that in tables (69b) and (69c) there are some shaded areas of systematic gaps. I have already discussed in section 3.1.1 for Wuhan that the gaps */dentalʲ/ is ruled out by a structural complexity constraint. I propose that the gaps */retroflexʲ/ is also ruled out by a complexity constraint. I show in (70) the two structural complexity constraints.

(70) Structural complexity constraints of */dentalɿ/ and */retroflexʅ/ in Linfen



3.2.3.2 /ɨ/ -->[u]

The second phonological vowel I discuss involves the surface form [u]. The surface form [u] in Linfen is distributed differently from that in Wuhan. Particularly, in Linfen, in the nucleus, [u] is found with all types of consonants. It is not restricted to occur with only labial or dorsal consonants, as in Wuhan (see section 3.1.3.2). I show the distribution in (71). Recall that /ɨ/ is, I will argue, the underlying representation of [u].

(71a) Distribution of [u] in the nucleus in Linfen

	/ʉ/
p	pu
p'	p'u
m	mu
f	fu
v	vu
t	tu
t'	t'u
n	
l	
ʦ	ʦu
ts'	ts'u
s	su
tʂ	tʂu
tʂ'	tʂ'u
ʂ	ʂu
ʐ	
k	ku
k'	k'u
ŋ	
x	xu
0	u

Further I show how [u] is distributed in the other syllable positions, i.e., in the coda and in the onset.

(71b) [u] appears in the coda in Linfen

	/ai/	/əi/	/^{E}ai/	/^{E}əi/
p	paw		p^{j}aw	
p'	p'aw		p^{j}'aw	
m	maw		m^{j}aw	
f				
v				
t	taw	təw	t^{j}aw	t^{j}əw
t'	t'aw	t'əw	t^{j}'aw	
n	naw	nəw	n^{j}aw	n^{j}əw
l		ləw	l^{j}aw	l^{j}əw
ʦ	ʦaw	ʦəw		
ts'	ts'aw	ts'əw		
s	saw	səw		
tʂ		tʂəw		
tʂ'		tʂ'əw		
ʂ		ʂəw		
ʐ		ʐəw		
k	kaw	kəw	ʨaw	ʨəw
k'	k'aw	k'əw	ʨ'aw	ʨ'əw
ŋ	ŋaw	ŋəw		
x	xaw	xəw	ɕaw	ɕəw
0			jaw	əw

I should point out here the sequence [əw]. When [ə] is followed by [w], it still surfaces as [ə]. As in Wuhan, [ə] does not change its place feature, say, to [o] because of [w]. In other words the place feature Labial on [w] does not affect [ə]. This suggests that the place feature Labial on [w] is not active in the phonology.

(71c) [u] occurs in the onset in Linfen

	/^{u}a/	/^{u}O/	/^{u}aE/	/^{u}əE/	/^{u}an/	/^{u}ən/	/^{u}aŋ/	/^{u}əŋ/
p								
p'								
m								
f								
v								
t				t^{w}ej	t^{w}an	t^{w}ən		t^{w}əŋ
t'				t^{w}'ej	t^{w}'an	t^{w}'ən		t^{w}'əŋ
n								
l					l^{w}an	l^{w}ən	l^{w}aŋ	
ts				ts^{w}ej	ts^{w}an	ts^{w}ən		ts^{w}əŋ
ts'				ts^{w}'ej	ts^{w}'an	ts^{w}'ən		ts^{w}'əŋ
s				s^{w}ej	s^{w}an	s^{w}ən		s^{w}əŋ
tʂ	tʂ^{w}a			tʂ^{w}ej	tʂ^{w}an	tʂ^{w}ən	tʂ^{w}aŋ	tʂ^{w}əŋ
tʂ'	tʂ^{w}'a			tʂ^{w}'ej	tʂ^{w}'an	tʂ^{w}'ən	tʂ^{w}'aŋ	tʂ^{w}'əŋ
ʂ				ʂ^{w}ej			ʂ^{w}aŋ	
ʐ								
k	k^{w}a	k^{w}o	k^{w}aj	k^{w}ej	k^{w}an	k^{w}ən	k^{w}aŋ	k^{w}əŋ
k'	k^{w}'a	k^{w}'o	k^{w}'aj	k^{w}'ej	k^{w}'an	k^{w}'ən	k^{w}'aŋ	k^{w}'əŋ
ŋ	ŋ^{w}a							
x	x^{w}a	x^{w}o	x^{w}aj	x^{w}ej	x^{w}an	x^{w}ən	x^{w}aŋ	x^{w}əŋ
0	wa	wo	waj	wej	wan	wən	waŋ	wəŋ

(shaded cells) systematic gaps of *[p^{W}]

I propose that the vowel [u] is underlyingly /ɨ/, which is placeless (and high). Recall that in Wuhan the evidence for the surface vowel [u] to be underlyingly placeless (i.e., /ɨ/) comes from two sources. One is that the distribution of [u] in the nucleus is conditioned by the onset consonant. It is reasonable to believe that [u] underlyingly lacks a place feature and assimilates to a consonant place feature. The other source of evidence comes from the inertness of the place feature of [u] when [u] occurs next to /ə/. When /ə/ occurs next to the glide [j], /ə/ is affected by [j] in place and becomes a front vowel [e]. However, when /ə/ occurs next to the glide [w], it is NOT affected by [w] in place, becoming, say, [o]. Instead it either remains as [ə] or is lengthened as [ɤ]. Again it is reasonable to believe that [w] does not affect /ə/ in place because [w] does not carry a place feature Labial underlyingly.

In Linfen, [u] in the nucleus is not conditioned by the consonant. However, there is evidence that the place feature Labial of [w] is inert when [w] occurs next to /ə/, particularly in comparison with the activeness of the place feature Coronal of [j] in the same environment. This suggests that the vowel [u] might lack underlyingly a place feature while [j] carries a place feature. I will address this again when I discuss the vowel /ə/.

3.2.3.3 /ə/--> [e], [ɤ], [ə]

The third vowel in Linfen is /ə/. The distributional pattern of this vowel is very similar to Wuhan. That is, when occurring next to [j], /ə/ surfaces as [e]. When occurring in an open syllable but not next to [j], /ə/ surfaces as [ɤ]. Otherwise /ə/ surfaces as [ə]. I show the distributions in (72).

(72) Distribution of [e]: /ə/ occurs next to [j]

	/əE/	/'əE/	/Eə/	/Eiə/
p	pej		p^{j}e	
p'	p'ej		p^{j}'e	
m	mej		m^{j}e	
f	fej			
v				
t	tej	t^{w}ej	t^{j}e	
t'		t^{w}'ej	t^{j}'e	
n	nej		n^{j}e	
l	lej		l^{j}e	l^{w}e
ʦ	ʦej	ʦ^{w}ej		
ts'	ts'ej	ts^{w}'ej		
s		s^{w}ej		
ʈʂ	ʈʂej	ʈʂ^{w}ej		
ʈʂ'		ʈʂ^{w}'ej		
ʂ		ʂ^{w}ej		
ʐ				
k	kej	k^{w}ej	ʨe	ʨ^{w}e
k'	k'ej	k^{w}'ej	ʨ'e	ʨ^{w}'e
ŋ				
x		x^{w}ej	ɕe	ɕ^{w}e
0		wej	je	ɥe

(shaded cells in the /Eə/ and /Eiə/ columns for ʦ through ʐ) systematic gaps

I have shown for Wuhan how /ə/ assimilates both progressively and regressively to [j] and surfaces as [e] (see section 3.1.3.3). The same happens in Linfen and again I analyze this as spreading the Coronal feature to /ə/, causing /ə/ to surface as a front vowel [e]. This suggests that [j] is underlyingly specified with the place feature Coronal.

(73) Distribution of [ɤ]: /ə/ occurs in an open syllable but not next to [j]

	/ə/
p	pɤ
p'	p'ɤ
m	mɤ
f	
v	
t	
t'	t'ɤ
n	
l	lɤ
ts	
ts'	
s	sɤ
ʈʂ	ʈʂɤ
ʈʂ'	ʈʂ'ɤ
ʂ	ʂɤ
ʐ	ʐɤ
k	kɤ
k'	k'ɤ
ŋ	ŋɤ
x	xɤ
0	

/ə/ is lengthened in an open syllable (but not following [j]) to [ɤ], driven by the requirement of Mandarin syllable structure discussed for Wuhan. Notice in the above table /ə/ does not assimilate in place to the preceding consonant. Recall in Wuhan /ə/, a V-place itself, only assimilates to another V-place, not to a C-place. This constraint holds for /ə/ in Linfen as well.

(74) Where /ə/ surfaces as [ə]: elsewhere

	/əɨ/	/ən/	/əŋ/	/^{w}ən/	/^{w}əŋ/	/^{E}əɨ/
p		pən	pəŋ			
p'		p'ən	p'əŋ			
m		mən	məŋ			
f		fən	fəŋ			
v			vəŋ			
t	təw	tən	təŋ	t^{w}ən	t^{w}əŋ	t^{j}əw
t'	t'əw	t'ən	t'əŋ	t^{w}'ən	t^{w}'əŋ	
n	nəw	nən	nəŋ			n^{j}əw
l	ləw	lən	ləŋ	l^{w}ən		l^{j}əw
ʦ	ʦəw	ʦən	ʦəŋ	$ʦ^{w}$ən	$ʦ^{w}$əŋ	
ts'	ts'əw			ts^{w}'ən	ts^{w}'əŋ	
s	səw	sən	səŋ	s^{w}ən	s^{w}əŋ	
tʂ	tʂəw	tʂən	tʂəŋ	$tʂ^{w}$ən	$tʂ^{w}$əŋ	
tʂ'	tʂ'əw	tʂ'ən	tʂ'əŋ	$tʂ^{w}$'ən	$tʂ^{w}$'əŋ	
ʂ	ʂəw	ʂən	ʂəŋ			
ʐ	ʐəw	ʐən	ʐəŋ			
k	kəw	kən	kəŋ	k^{w}ən	k^{w}əŋ	tɕəw
k'	k'əw	k'ən	k'əŋ	k^{w}'ən	k^{w}'əŋ	tɕ'əw
ŋ	ŋəw	ŋən				
x	xəw	xən	xəŋ	x^{w}ən	x^{w}əŋ	ɕəw
0				wən	wən	jəw

[shaded box] systematic gaps

Sequences in the above table are similar to Wuhan and have already been addressed in section 3.1.1. For instance, in the sequence /əw/, /ə/ does not assimilate to /ɨ/, indicating that the place feature is underlyingly absent on /ɨ/. In sequences /ən, əŋ, ^{w}ən, and ^{w}əŋ/, /ə/ does not assimilate to a consonant in Linfen either. In the sequence /^{j}əw/, /ə/ does not c-command /E/ and so does not assimilate to /E/.

To summarize the vowel /ə/, this vowel has three surface variants. [e] is found when next to [j], a result of place assimilation to the latter. [ɣ] is found in an open syllable but not following [j], a result of lengthening driven by the requirement of syllable structure. [ə] is found elsewhere. Further, /ə/ only assimilates in place to another vowel, not consonant, and this vowel has to be the closest segment to /ə/ in structure.

Before I move on to the last vowel, I present one more piece of evidence to show that in Linfen the place feature Coronal of [i] must be present underlyingly, apart from the distributional evidence that [i] causes a neighboring /ə/ to assimilate in place. The evidence is diminutive *r*-suffixation. In Linfen, when the diminutive suffix *-r* is attached to the stem, the following patterns are found (Chen and Li 1996; Wuhan does not show these patterns of *r*-suffixation).

(75) R-suffixation patterns in Linfen

(A) When stem ends with segment other than /i/ or /n/:

	a --> ar	o --> or	u --> ur	ia --> iar
	ua --> uar	uo --> uor	au --> aur	əu --> əur
	jau --> jaur	jəu --> jəur		

(B) When stem ends with /i or n/:

(i)	i --> iər			
(ii)	ai --> ar	an --> ar	ei --> ər	ən --> ər
	ian --> iar	uai --> uar	uan --> uar	iən --> iər
	uei --> uər	uən --> uər		

The patterns show that when the stem ends with a segment other than /i, n/, /r/ is attached directly as the suffix. However, when the stem ends with /i/ or /n/, changes happen. In an open syllable, /ə/ is inserted between the stem and /r/ (see 75Bi). In a closed syllable, the coda segment of the stem is eliminated when /r/ is attached (see 75Bii). Assuming that /i, n/ are both specified with the place feature Coronal, and assuming that /r/ is also specified with the place feature Coronal (see Wu 1994 for arguments), I argue that when /r/ is attached to a stem ending with /i/ or /n/, two adjacent Coronal nodes are found, which creates an OCP violation, as expressed below.

(76) OCP constraint against two adjacent Coronal segments in rime in Linfen

```
*     X            Y
      Rt           Rt
      |            |
      C-Pl/V-Pl    C-Pl
      |            |
      Coronal      Coronal
      Domain : in the rime
```

I show how sequences in (75Bi) and (75Bii) are derived. First, I show how /i/ + /r/ --> [iər] in (75Bi).

(77) How /i/ + /r/ --> [iər] in Linfen

(a) Underlying (ignoring other features of /i/ and /r/)

```
      /i/    +     /r/
      Rt           Rt
      |            |
      V-Pl         C-Pl
      |            |
      Coronal      Coronal             <--- OCP violation
```

(b) Repair strategy: /ə/ inserted

```
      /i/          /ə/    /r/
      Rt           Rt     Rt
      |            ...    |
      V-Pl                C-Pl
      |                   |
      Coronal             Coronal
```

(c) Surface: [iər]

In (77a), the OCP is violated since there are two adjacent segments both specified with Coronal. To solve the problem, in (77b) /ə/ is inserted. Since /i/ and /r/ are no longer adjacent to each other on the segment level, the OCP is not violated. Hence [iər].

Having shown how sequences in (75Bi) are derived, I show how sequences in (75Bii) are derived. I take /an/ + /r/ -> [ar] as an example.

(78) How /an/ + /r/ -> [ar] in Linfen

(a) Underlying (ignoring other features of /i/ and /r/)

```
/a/     /n/      +     /r/
...     Rt             Rt
        |              |
        C-Pl           C-Pl
        |              |
        Coronal        Coronal            <--- OCP violation
```

(b) Repair strategy: /n/ deleted

```
/a/          /r/
...          Rt
             |
             C-Pl
             |
             Coronal
```

(c) Surface: [ar]

In (78a), the OCP is violated since there are two adjacent segments both specified with Coronal. To solve the problem, /n/ is deleted in (78b). Notice unlike (77), /ə/ is not inserted here as a repair strategy. The result of /ə/ insertion would be [anər]. I assume that no extra syllable is allowed in the process of *r*-suffixation.[19] Instead, /n/ is deleted. Hence [ar].

A comment on the forms au --> aur, əu --> əur, jau --> jaur, jəu --> jəur in (75A) is in order. In these r-suffixed rimes, there are three segments. For instance, in [aur], assuming [a] is in the nucleus, there are two segments, [u] and [r], in the coda. This presents a problem for our assumptions about Mandarin syllable structure, i.e., that only one segment is allowed in the coda. There are two possible solutions here. One is to follow the proposal of Wu 1994 for Beijing Mandarin in treating the r-suffix as a featural suffix, not a segmental one ([aur] would then be [au^r]; superscript [r] indicating the feature Retroflex on [u]). Thus there is only one segment in the coda in the cases mentioned. The Mandarin syllable structure requirement is met. The other solution is to suggest that the Mandarin syllable structure assumed only holds of morphologically non-derived forms. In morphologically derived forms, a branching coda is allowed. I leave this for further research.

To summarize the r-suffixation patterns in Linfen, the vowel /i/ patterns in the same way as /n/ (specified with Coronal) in that both resist being adjacent to another coronal segment /r/. Based on this behaviour of /i/, I conclude that the place feature Coronal must be present

---

[19]This can be regarded as a constraint in Mandarin that repairs cannot add syllables.

underlyingly on this vowel, supporting the conclusion drawn earlier from the distributional patterns of [i].[20]

3.2.3.4 /a/ --> [a]

The fourth vowel is /a/, unspecified for place as a central vowel. Like /a/ in Wuhan, /a/ in Linfen does not assimilate in place to another segment. It surfaces as [a]. I have addressed the inertness of /a/ for Wuhan, comparing /a/ with the other two central vowels /ɨ/ and /ə/.

(79) Distribution of [a]: to be continued

	/a/	/aE/	/aɨ/	/an/	/aŋ/	/ᴱa/	/ᴱaE/	/ᴱaɨ/	/ᴱan/	/ᴱaŋ/
p	pa	paj	paw	pan	paŋ	pʲa		pʲaw	pʲan	
p'	p'a	p'aj	p'aw	p'an	p'aŋ	pʲ'a		pʲ'aw	pʲ'an	
m	ma	maj	maw	man	maŋ	mʲa		mʲaw	mʲan	
f	fa	faj		fan	faŋ					
v	va				vaŋ					
t	ta	taj	taw	tan	taŋ	tʲa		tʲaw	tʲan	
t'	t'a	t'aj	t'aw	t'an	t'aŋ	tʲ'a		tʲ'aw	tʲ'an	
n	na	naj	naw	nan	naŋ	nʲa		nʲaw	nʲan	nʲaŋ
l	la	laj			laŋ	lʲa		lʲaw	lʲan	lʲaŋ
ʦ	ʦa	ʦaj	ʦaw	ʦan	ʦaŋ	(gap)	(gap)	(gap)	(gap)	(gap)
ts'	ts'a	ts'aj	ts'aw	ts'an	ts'aŋ	(gap)	(gap)	(gap)	(gap)	(gap)
s	sa	saj	saw	san	saŋ	(gap)	(gap)	(gap)	(gap)	(gap)
ʈʂ	ʈʂa	ʈʂaj				(gap)	(gap)	(gap)	(gap)	(gap)
ʈʂ'	ʈʂ'a	ʈʂ'aj				(gap)	(gap)	(gap)	(gap)	(gap)
ʂ	ʂa	ʂaj				(gap)	(gap)	(gap)	(gap)	(gap)
ʐ	ʐa					(gap)	(gap)	(gap)	(gap)	(gap)
k	ka	kaj	kaw	kan	kaŋ	ʨa	ʨaj	ʨaw	ʨan	ʨaŋ
k'	k'a	k'aj	k'aw	k'an	k'aŋ	ʨ'a		ʨ'aw	ʨ'an	ʨ'aŋ
ŋ	ŋa	ŋaj	ŋaw	ŋan	ŋaŋ					
x	xa	xaj	xaw	xan	xaŋ	ʨ'a	ɕaj	ɕaw	ɕan	ɕaŋ
0	a					ja		jaw	an	jaŋ

(gap) = systematic gaps

[20] Although the feature specification of [i] is supported by evidence from both the distribution of [i] and from r-suffixation in the language, the feature specification of the other vowel [u] (proposed /ɨ/; feature Labial absent underlyingly) is only supported by the distribution of [u].

(79) Distribution of [a]: continued

	/ᵘa/	/ᵘaE/	/ᵘan/	/ᵘaŋ/	/ᴱⁱa/	/ᴱⁱan/
p						
p'						
m						
f						
v						
t			tʷan			
t'			tʷ'an			
n						
l			lʷan	lʷaŋ		
ʦ			ʦʷan			
ts'			tsʷ'an			
s			sʷan			
tʂ	tʂʷa		tʂʷan	tʂʷaŋ		
tʂ'	tʂʷ'a		tʂʷ'an	tʂʷ'aŋ		
ʂ				ʂʷaŋ		
ʐ						
k	kʷa	kʷaj	kʷan	kʷaŋ	ʨʷa	ʨʷan
k'	kʷ'a	kʷ'aj	kʷ'an	kʷ'aŋ	ʨʷ'a	ʨʷ'an
ŋ	ŋʷa					
x	xʷa	xʷaj	xʷan	xʷaŋ	ɕʷa	ɕʷan
0	wa	waj	wan	waŋ		ɥan

(shaded cells) systematic gaps

3.2.3.5 /O/ --> [o]

The fifth vowel is /O/, specified with place feature Labial. This vowel surfaces as [o].

(80) Distribution of [o]

	/O/	/^{u}O/	/^{Eu}O/
p	po		
p'	p'o		
m	mo		
f	fo		
v	vo		
t	to		
t'	t'o		
n	no		n^{ɥ}o
l	lo		l^{ɥ}o
ts	tso		
ts'	ts'o		
s	so		
tʂ	tʂo		
tʂ'	tʂ'o		
ʂ	ʂo		
ʐ	ʐo		
k	ko	k^{v}o	tɕ^{v}o
k'	k'o	k^{v}'o	tɕ^{v}'o
ŋ	ŋo		
x	xo	x^{v}o	ɕ^{v}o
0	o	wo	ɥo

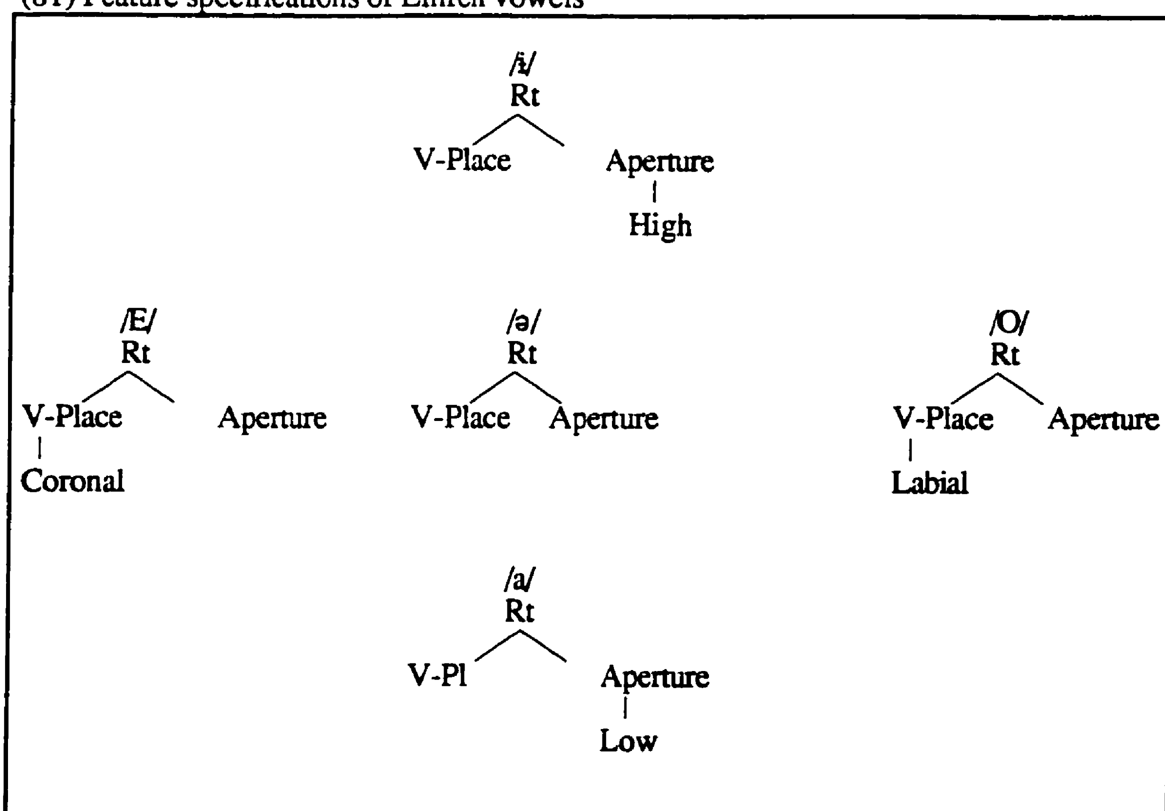
(shaded cells) systematic gaps

Notice in the above table [o] only appears in an open syllable. It is not found in a closed syllable (with a coda segment being either glide or nasal in Mandarin). In this respect Linfen is different from Wuhan, where [o] does occur in a closed syllable such as [oŋ]. Recall that /O/ in Wuhan is not affected by default High insertion because of the neutralization of two phonemes /O/ and /ɨ/. See section 3.1.4.

Above is the discussion of the five-vowel system of Linfen, focusing on place feature specifications. Linfen has the same vowel inventory as Wuhan in that there are three central vowels, one front vowel, and one back vowel. I propose that the three central vowels are distinguished from each other in that /a/ is specified with Low and /ɨ/ is specified with High, with /ə/ unspecified for a height feature. Following the arguments for Wuhan, I propose that the front vowel /E/ and the back vowel /O/ are unspecified for height based on the lack of height contrast among front vowels and among back vowels. Further, the front vowel /E/ surfaces through a default rule of High. The back vowel /O/, however, does not receive a default feature High, since such a result [u] would cause surface neutralization with another phoneme /ɨ/ (which also surfaces as [u]), which is not allowed in the language. I have shown the details of derivations in section 3.1.2 for Wuhan and do not repeat them for Linfen.

Below is a summary of the feature specifications of the vowels in Linfen.

(81) Feature specifications of Linfen vowels



3.3 Concluding remarks

In this chapter I have introduced two five-vowel inventories in Mandarin. I have shown in detail, based on the distribution of the surface vowels and their phonology in each language, that these five-vowel phonological inventories in Mandarin languages are identical phonologically and are realized differently on the surface. In particular, the central vowel /ɨ/ in Wuhan is realized on the surface by assimilation and default, while the same vowel is realized simply by default in Linfen.

Wuhan and Linfen represent two types of five-vowel inventories in Mandarin languages. Other five-vowel Mandarin inventories have also been found in my study. These languages include: Chongqing, Guiyang, Dali, Jishou, Liping, Zigong, Chengdu, Xichang, Nanchong, Changde, Shangqiu, Zhengzhou, Linxian, Huhehaote, and Suide. I did not include these inventories in this chapter for lack of evidence for feature specifications. Recall from this chapter that the evidence for determining feature specifications of a vowel inventory (for both Wuhan and Linfen type) comes from distribution of surface vowels. In particular, we notice that in both types the vowel /ə/ assimilates in place to a neighboring segment [i] but not [u], showing that the place feature of [i] is active and thus present underlyingly, while the place feature of [u] is inert and thus absent underlyingly. Such evidence, however, is not found with the languages given above, according to the available data (Chen and Li 1996). I take Chongqing for illustration.

(82) Surface vowel inventory of Chongqing:

	Front		Central	Back	
	Unrounded	Rounded	Unrounded	Unrounded	Rounded
High	i	ü	ı		u
Mid	e				o
Low			a		

The surface inventory is close to that of Wuhan (see 3), but is missing the vowels [ə] and [ɤ]. Assuming that [ü] is not an underlying vowel (derived from two vowels) and that [ɿ] is a surface variant of /i/ (as in Wuhan and Linfen), we have the following five phonemes for Chongqing:

(83) Five phonemes of Chongqing

i		u
e		o
	a	

No evidence has been found to support the feature specifications of the vowels in this inventory. For instance, there is no assimilation (since there is no phoneme /ə/, which is the target of assimilation in Wuhan and Linfen). There is no clue from the OCP. For instance, sequences [je] and [ej] are fine (two adjacent coronal segments), as is sequence [ou] (two adjacent labial segments). The r-suffixation data in this language do not provide any evidence either. It is hoped that future fieldwork could provide more details about these languages in order to determine the nature of their phonological inventories.

The languages discussed in this chapter present strong confirmation for the contrastive specification approach outlined in Chapter 2. Given that there is only one phonological high vowel, this theory predicts that that vowel would be inert with respect to place of articulation phonology: it contrasts with no other place at its height. This prediction is borne out in that the surface vowel [u] is not involved in phonological processes while [i] (from /E/), is an assimilation trigger in both languages. The vowel /O/ too requires a feature by this theory and this feature spreads (see (28)).

Chapter 4 Mandarin four-vowel inventories

In this chapter I examine Mandarin languages with four-vowel inventories. I have selected for discussion two representative languages, Chengde and Harbin. In section 4.1 I examine the phonological vowel inventory of Chengde. In section 4.2 I examine the phonological vowel inventory of Harbin. In section 4.3 I address the assimilation patterns of central vowels arising from the discussion of these Mandarin languages. In section 4.4 I draw a conclusion for the chapter. When compared with the five-vowel inventories discussed in the previous chapters, it will be seen that two different phonological inventories can be realized as the same phonetic inventory.

4.1 Chengde

Languages in this type include Chengde, Tangshan, Baoding, Cangzhou, Shijiazhuang, Tianshui, Hanzhong, Lingbao, Jinzhou, Yangyuan, Handan, Dandong, Hailar, Yuanyang, Hami, Urumchi, Beijing, Tianjin, and Yantai. Chengde is taken as an example for illustration. The data on Chengde come from Chen and Li 1996.

4.1.1 Consonants

First I introduce the consonant system of Chengde. The surface consonant inventory of Chengde is given in (1).

(1) Phonetic inventory of consonants of Chengde

		Labial	Alveolar	Dental	Retroflex	Palatal	Velar
Stops and affricates	-asp	p	t	ts	tʂ	tɕ	k
	+asp	p'	t'	ts'	tʂ'	tɕ'	k'
Fricatives		f		s	ʂ, ʐ	ɕ	x
Sonorants		m	n, l				ŋ

As discussed in Chapter 2, Mandarin surface consonant inventories vary mainly in the presence/absence of retroflexes. Among the languages we have seen, Wuhan does not have retroflexes, whereas Linfen does. Chengde also has retroflex consonants. The presence of retroflexes in this language implies the existence of the surface vowel [ʅ]. Recall from section 3.1 of Chapter 3 that the apical vowel [ʅ] is the vocalic continuation of a preceding retroflex consonant and so only exists when such a consonant precedes.

I have argued that surface palatals in Mandarin are not underlying consonants but rather velar consonants with palatalization. Thus the phonological inventory of Chengde includes only five places of articulation, as shown in (2).

(2) Phonological inventory of consonants of Chengde

		Labial	Alveolar	Dental	Retroflex	Velar
Stops and affricates	-asp	p	t	ts	ʈʂ	k
	+asp	p'	t'	ts'	ʈʂ'	k'
Fricatives		f		s	ʂ, ʐ	x
Sonorants		m	n, l			ŋ

Among different features of consonants, only place features are relevant for our examination of vowels. See Chapter 2 for place feature specifications of labial, alveolar, dental, retroflex, and velar consonants. Next I examine the vowels.

4.1.2 Vowel inventory: phonetic

First I provide the surface vowel inventory of Chengde.

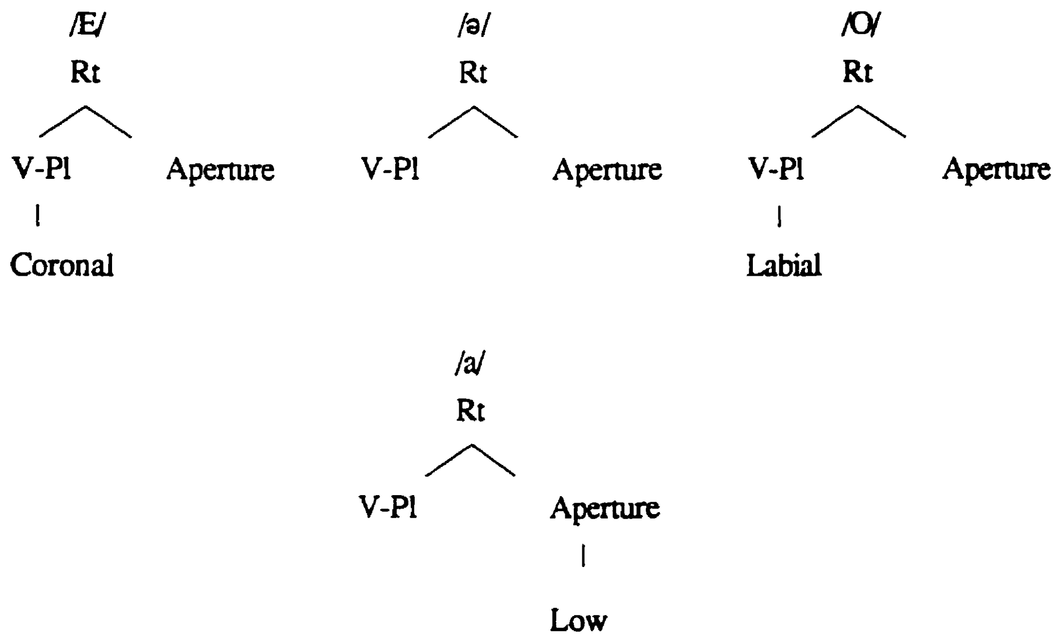
(3) Surface vowel inventory of Chengde

	Front		Central	Back	
	Unrounded	Rounded	Unrounded	Unrounded	Rounded
High	i	ü	ɿ	ʅ	u
Mid	e		ə	ɤ	o
Low			a		

Notice that this surface inventory is *identical* with the surface inventory of Linfen (see table 48 of Chapter 3). I will show after discussing Chengde, how two *identical* surface inventories are derived from two *different* phonological inventories.

I propose that the surface vowels in table (3) are derived from four underlying vowels, represented in structural terms below.

(4) Structural representations of the four vowels in Chengde



This is a two-height inventory. /a/ is a Low vowel, and the other three are non-low. Among the three non-low vowels, there is a front vowel, marked with Coronal, a central vowel, unmarked for place feature, and a back vowel, marked with Labial. All three are phonologically non-low and non-high, or in other words unspecified for height.

Next I show how the vowels in the surface inventory in table (3) are derived from the four underlying vowels. First I present the distributional patterns of each phonological vowel and its surface variants.

(5) Distributions of each phonological vowel and its surface variants in Chengde

/E/ -->	[ɿ]	after a dental consonant in the nucleus
	[ʅ]	after a retroflex consonant in the nucleus
	[i]	elsewhere
/O/ -->	[u]	
/ə/-->	[e]	following or preceding glide [j]
	[o]	following or preceding glide [w]
	[ɤ]	in open syllable but not following glide [j] or [w]
	[ə]	elsewhere
/a/-->	[a]	

The vowel /E/, with a Coronal place feature, has three surface variants, [i], [ɿ], and [ʅ]. This pattern is familiar to us from Linfen. The vowel /O/, with a Labial place feature, surfaces simply as [u]. The vowel /ə/, with neither place nor height features, has four surface variants, [e], [o], [ə], and [ɤ]. Lastly the vowel /a/, with the height feature Low, surfaces simply as [a]. The pattern of this vowel is not strange to us either since we have seen it in both Wuhan and Linfen.

In the next section I go through the distribution of each vowel. Again my discussion is focused around two major aspects of the vowels, i.e., the place and the height specifications. I examine place first, assuming height features as proposed for the moment. For better illustration, I start with the vowel /ə/ for this language. This is because the distribution of this vowel provides crucial evidence for the place specifications of the other two vowels /E/ and /O/.

4.1.3 Place features

4.1.3.1 /ə/ --> [e], [o], [ɤ], [ə]

The vowel /ə/ has four surface variants occurring in complementary environments. [e] occurs when next to the glide [j]. [o] occurs when next to the glide [w]. [ɤ] occurs in an open syllable but not following the glide [j]. [ə] occurs elsewhere. I present each of the distributions below.

(6) Variant [e]: next to glide [j]

	/əE/	/OəE/	/Eə/	/OEə/
p	pej		p^{j}e	
p'	p'ej		p^{j}'e	
m	mej		m^{j}e	
f	fej			
t		t^{w}ej	t^{j}e	
t'		t^{w}'ej	t^{j}'e	
n	nej		n^{j}e	n^{ɥ}e
l	lej		l^{j}e	l^{ɥ}e
ʦ	ʦej	ʦ^{w}ej		
ts'		ts^{w}'ej		
s		s^{w}ej		
ʈʂ		ʈʂ^{w}ej		
ʈʂ'		ʈʂ^{w}'ej		
ʂ		ʂ^{w}ej		
ʐ		ʐ^{w}ej		
k	kej	k^{w}ej	ʨe	ʨ^{w}e
k'		k^{w}'ej	ʨ'e	ʨ^{w}'e
ŋ				
x	xej	x^{w}ej	ɕe	ɕ^{w}e
0		wej	je	ɥe

systematic gaps

As suggested in the table in (6), the surface vowel [e] is always found next to the glide [j]. In other words the appearance of [e] is conditioned by the existence of [j]. I propose that [e] is a result of place assimilation of /ə/ to the neighboring /E/. I have shown similar assimilation processes in section 3.1.1 of Chapter 3 for Wuhan. I do not repeat them here.

The fact that the vowel /E/ (glide [j] when syllabified in the non-nucleus) affects the neighbouring /ə/ in spreading its place feature suggests that the place feature Coronal is active in Chengde and so is present underlyingly.

A comment is required on /uiə/ in the above table. This sequence surfaces as [^{ɥ}e]. For instance, /nOEə/ -> [n^{ɥ}e]. I will show in a moment that the vowel /O/ is specified with the feature Labial underlyingly. Thus in /nuiə/, there are two vowels, /E/ and /O/, both specified with a place feature. However, /E/ spreads the place feature Coronal to /ə/. /O/ does not spread the place feature Labial to /ə/ causing it to be rounded as [o]. I propose that this is accounted for by ordering the rule of Coronal spreading before the rule of Labial spreading. That is to say, in the case /nuiə/ surfacing as [n^{ɥ}e], the application of Coronal spreading onto /ə/ applies first and thus blocks the application of Labial spreading onto /ə/.

Notice in table (6) the sequence /uəi/ surfaces as [^{v}ej]. That is, /ə/ assimilates in place to /E/, not to /O/. I have discussed in section 3.1.1 that this is because /ə/ c-commands /E/, not /O/, and the target must c-command the trigger in order for assimilation to occur in Mandarin.

(7) Variant [o]: next to glide [w]

	/əO/	/EəO/	/Oə/
p			
p'			
m	mow		
f	fow		
t	tow	tʲow	$t^{w}o$
t'	t'ow		t^{w}'o
n		nʲow	$n^{w}o$
l	low	lʲow	$l^{w}o$
ʦ	ʦow		$ʦ^{w}o$
ts'	ts'ow		ts^{w}'o
s	sow		$s^{w}o$
tʂ	tʂow		$tʂ^{w}o$
tʂ'	tʂ'ow		$tʂ^{w}$'o
ʂ	ʂow		$ʂ^{w}o$
ʐ	ʐow		$ʐ^{w}o$
k	kow	ʨow	$k^{w}o$
k'	k'ow	ʨ'ow	k^{w}'o
ŋ	ŋow		
x	xow	ɕow	$x^{w}o$
0	ow	jow	wo

[shaded box] systematic gaps

This table is a mirror image of table (6). The surface form [o] is found only when next to the glide [w]. In other words the appearance of [o] is conditioned by a neighbouring [w]. I propose the form [o] is a result of place assimilation of /ə/ to the glide [w]. I take [tow] ("steal") and [$k^{w}o$] ("pot") as examples and show the processes.

(8) /təO/ --> [tow] ("steal")

(a) Underlying

t	ə	O
Rt	Rt	Rt
|	|	|
C-Pl	V-Pl	V-Pl
|		|
Coronal		Labial

(b) /O/ spreading feature Labial onto /ə/

t	ə	O
Rt	Rt	Rt
|	|	|
C-Pl	V-Pl	V-Pl
|	- - - - - - - - -	|
Coronal		Labial

(c) Surface: [tow] ("steal")

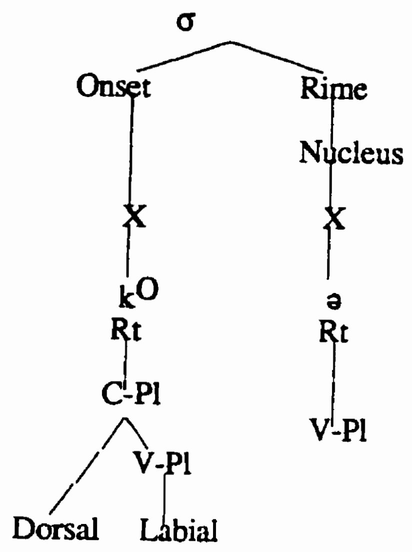
In (8b) the feature Labial on /O/ spreads regressively onto /ə/, resulting in the surface form [tow].

(9) /kOə/ --> [k^wo] ("pot")

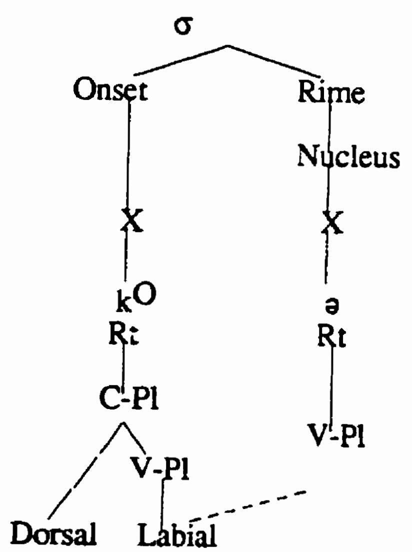
(a) Underlying /kOə/

k	O	ə
Rt	Rt	Rt
|	|	|
C-Pl	V-Pl	V-Pl
|	|	
Dorsal	Labial	

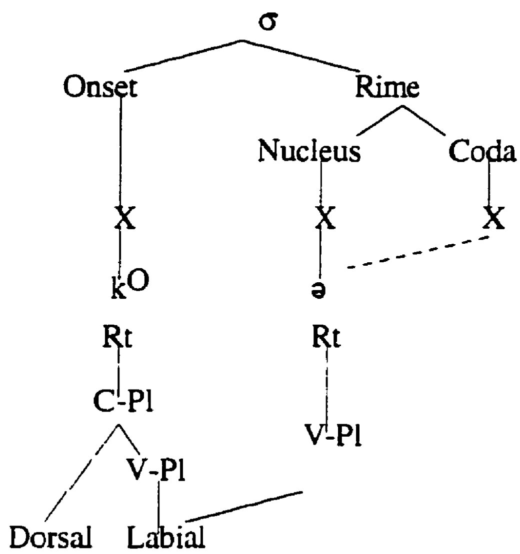
(b) After syllabification



(c) Spreading of Labial



(d) Open syllable vowel lengthening



(e) Surface form: [k^{w}o] ("pot")

In (9c) the feature Labial on /O/ spreads progressively onto /ə/. In (9d) /ə/ is lengthened to take both slots of the rime (I do not show this in the phonetic transcription). Hence the surface form [k^{w}o].

The fact that the vowel /O/ affects the neighbouring /ə/ in spreading its place feature suggests that the place feature Labial is active in Chengde and so is present underlyingly on /O/.

Notice in the above table the sequence /iəu/ surfaces as [ʝow]. That is, /ə/ assimilates in place to /O/, not to /E/. I have discussed in section 3.1.1 that this is because /ə/ c-commands /O/, not /E/, and the target should c-command the trigger in Mandarin.

(10) Variant [ɤ]: in an open syllable but not following glide [j] or [w]

	/ə/
p	pɤ
p'	p'ɤ
m	mɤ
f	fɤ
t	tɤ
t'	t'ɤ
n	
l	lɤ
ts	tsɤ
ts'	ts'ɤ
s	sɤ
ʈʂ	ʈʂɤ
ʈʂ'	ʈʂ'ɤ
ʂ	ʂɤ
ʐ	ʐɤ
k	kɤ
k'	k'ɤ
ŋ	ŋɤ
x	xɤ
0	

The surface form [ɤ], the third variant of /ə/, is found in an open syllable, preceded by a consonant. [ɤ] can be viewed as a lengthened version of /ə/. I have discussed in Chapter 3 that the lengthening of /ə/ to [ɤ] is driven by requirements of syllable structure in Mandarin. That is, bimoraicity is required on the surface, and /ə/, being the only segment in the rime, is lengthened to occupy the two timing slots of the rime.

The fourth variant of /ə/ is [ə].

(11) Variant [ə]: elsewhere

	/ən/	/əŋ/	/Eən/	/Eəŋ/	/Oən/	/Oəŋ/	/OEən/	/OEəŋ/
p	pən	pəŋ	pʲən	pʲəŋ				
p'	p'ən	p'əŋ	pʲ'ən	pʲ'əŋ				
m	mən	məŋ	mʲən	mʲəŋ				
f	fən	fəŋ						
t		təŋ		tʲəŋ	tʷən	tʷəŋ		
t'		t'əŋ		tʲ'əŋ	tʷ'ən	tʷ'əŋ		
n		nəŋ		nʲəŋ	nʷən	nʷəŋ		
l		ləŋ	lʲən	lʲəŋ	lʷən	lʷəŋ		
ʦ	ʦən	ʦəŋ			ʦʷən	ʦʷəŋ		
ts'		ts'əŋ			tsʷ'ən	tsʷ'əŋ		
s		səŋ			sʷən	sʷəŋ		
tʂ	tʂən	tʂəŋ			tʂʷən	tʂʷəŋ		
tʂ'	tʂ'ən	tʂ'əŋ			tʂʷ'ən	tʂʷ'əŋ		
ʂ	ʂən	ʂəŋ			ʂʷən			
ʐ	ʐən	ʐəŋ			ʐʷən	ʐʷəŋ		
k	kən	kəŋ	ʨən	ʨəŋ	kʷən	kʷəŋ	ʨʷən	ʨʷəŋ
k'	k'ən	k'əŋ	ʨ'ən	ʨ'əŋ	kʷ'ən	kʷ'əŋ	ʨʷ'ən	ʨʷ'əŋ
ŋ	ŋən							
x	xən	xəŋ	ɕən	ɕəŋ	xʷən	xʷəŋ	ɕʷən	ɕʷəŋ
0			jən	jəŋ	wən	wəŋ	ɥən	ɥəŋ

systematic gaps

[ə] occurs in environments other than those for the other three variants [e], [o], and [ɤ]. In the above table, /ə/ is followed by a nasal segment in the coda, [n] or [ŋ]. /ə/ does not assimilate to the nasal, since /ə/ only assimilates to a vowel, not to a consonant, or a C-place. Recall that this is also true for Wuhan and Linfen. Further, in the above table, when /ə/ is preceded by a glide [j] ~ [w] and followed by a nasal, it does not assimilate to the preceding glide, as it does in other environments such as /ᴱə/, /ᴼə/, /əE/, and /əO/. I have discussed similar phenomena for Wuhan and Linfen in Chapter 3. That is, the target has to c-command the trigger. In these cases /ə/ does not c-command the preceding [j] ~ [w] and so does not assimilate to [j] ~ [w].

I summarize the discussion of the vowel /ə/. This vowel has four surface variants occurring in complementary distribution, [e], [o], [ɤ], and [ə]. The fact that /ə/ assimilates to /E/ and /O/ in place suggests that the place features on these two segments, Coronal and Labial respectively, are active in the phonology and should be both specified underlyingly. Further, /ə/ only assimilates to the segment structurally closest to itself, if that segment is a possible trigger.

4.1.3.2 /E/ --> [ɿ], [ʅ], [i]

The second vowel, /E/, has three surface variants in complementary environments. The form [ɿ] is found only in the nucleus and following a dental consonant. [ʅ] is found only in the nucleus and following a retroflex consonant. The form [i] is found in environments other than these. I show the distributions below.

(12) Where [ɿ] is found in Chengde: in the nucleus of an open syllable and following a dental

	/E/
p	
p'	
m	
f	
t	
t'	
n	
l	
ts	tsɿ
ts'	ts'ɿ
s	sɿ
tʂ	
tʂ'	
ʂ	
ʐ	
k	
k'	
ŋ	
x	
0	

The distribution of the surface vowel [ɿ] is very limited. It only occurs in the nuclear position of an open syllable AND following a dental consonant.

(13) Where [ʅ] is found in Chengde: in the nucleus and following a retroflex

	/E/
p	
p'	
m	
f	
t	
t'	
n	
l	
ts	
ts'	
s	
tʂ	tʂʅ
tʂ'	tʂ'ʅ
ʂ	ʂʅ
ʐ	ʐʅ
k	
k'	
ŋ	
x	
0	

Similar to [ɿ], the surface vowel [ʅ] is also only found in the nuclear position BUT following a retroflex consonant instead. [ɿ] and [ʅ] together are in a complementary distribution with the surface form [i], as shown below.

(14) [i] is found in the nucleus in Chengde

	/E/
p	pi
p'	p'i
m	mi
f	
t	ti
t'	t'i
n	ni
l	li
ts	
ts'	
s	
tʂ	
tʂ'	
ʂ	
ʐ	
k	tɕi
k'	tɕ'i
ŋ	
x	ɕi
0	i

When [i] occurs in the nucleus, it follows a labial, coronal, or a dorsal consonant, and is in complementary distribution with the other two vowels [ɿ] and [ʅ]. I have shown in Chapter 3 the process of /E/ assimilating to the place feature of a preceding dental or retroflex consonant (see sections 3.1.3.1 and 3.2.3.1). The process is not repeated. The surface vowel [i] is found not only in the nucleus, but also in the coda and the onset. I show the distributions.

(15) [i] appears in the coda in Chengde

	/əE/	/aE/	/OəE/	/OaE/
p	pej	paj		
p'	p'ej	p'aj		
m	mej	maj		
f	fej			
t		taj	t^{w}ej	
t'		t'aj	t^{w}'ej	
n	nej	naj		
l	lej	laj		
ʦ	ʦej	ʦaj	ʦ^{w}ej	
ts'		ts'aj	ts^{w}'ej	
s		saj	s^{w}ej	s^{w}aj
tʂ		tʂaj	tʂ^{w}ej	tʂ^{w}aj
tʂ'		tʂ'aj	tʂ^{w}'ej	tʂ^{w}'aj
ʂ		ʂaj	ʂ^{w}ej	ʂ^{w}aj
ʐ			ʐ^{w}ej	
k	kej	kaj	k^{w}ej	k^{w}aj
k'		k'aj	k^{w}'ej	k^{w}'aj
ŋ		ŋaj		
x	xej	xaj	x^{w}ej	x^{w}aj
0		aj	wej	waj

[shaded box] systematic gaps

(16) [i] appears in the onset in Chengde

	/Eə/	/Ea/	/EəO/	/EaO/	/Eən/	/Ean/	/Eəŋ/	/Eaŋ/
p	pʲe			pʲaw	pʲən	pʲan	pʲəŋ	
p'	pʲ'e			pʲ'aw	pʲ'ən	pʲ'an	pʲ'əŋ	
m	mʲe			mʲaw	mʲən	mʲan	mʲəŋ	
f								
t	tʲe		tʲow	tʲaw		tʲan	tʲəŋ	
t'	tʲ'e			tʲ'aw		tʲ'an	tʲ'əŋ	
n	nʲe		nʲow	nʲaw		nʲan	nʲəŋ	nʲaŋ
l	lʲe		lʲow	lʲaw	lʲən	lʲan	lʲəŋ	lʲaŋ
ts								
ts'								
s								
tʂ								
tʂ'								
ʂ								
ʐ								
k	tɕe	tɕa	tɕow	tɕaw	tɕən	tɕan	tɕəŋ	tɕaŋ
k'	tɕ'e	tɕ'a	tɕ'ow	tɕ'aw	tɕ'ən	tɕ'an	tɕ'əŋ	tɕ'aŋ
ŋ								
x	ɕe	ɕa	ɕow	ɕaw	ɕən	ɕan	ɕəŋ	ɕaŋ
0	je	ja	jow	jaw	jən	jan	jəŋ	jaŋ

(shaded) systematic gaps

Since the three vowels [ɿ], [ʅ], and [i] are in complementary distribution and [i] is the most widely distributed, I treat them as allophones of underlying vowel /E/. When I discussed the vowel /ə/, I showed that the vowel [i] causes the central /ə/ to surface as the front vowel [e], suggesting that the place feature on [i] is active in the phonology and thus is present underlyingly.

In section 3.2 of Chapter 3 I argued for Linfen that support for the presence of the feature Coronal on /E/ comes not only from the distributional patterns of /E/, but also from diminutive r-suffixation in the language. The r-suffixation patterns in Chengde are similar to those in Linfen. That is, /E/ patterns in the same way as /n/ (specified with place feature

Coronal) in that both resist being adjacent to another coronal segment /r/. This suggests that the place feature Coronal must be present underlyingly on /E/. I do not give details here; see Chapter 3, section 3.2.3.3 for discussion.

4.1.3.3 /O/ --> [u]

The surface form [u] is distributed in the following ways.

(17) [u] is found in the nucleus in Chengde

	/O/
p	pu
p'	p'u
m	mu
f	fu
t	tu
t'	t'u
n	nu
l	lu
ʦ	ʦu
ts'	ts'u
s	su
tʂ	tʂu
tʂ'	tʂ'u
ʂ	ʂu
ʐ	ʐu
k	ku
k'	k'u
ŋ	
x	xu
0	

When appearing in the nucleus, [u] follows all types of consonants. Recall that in Wuhan, the appearance of [u] in the nucleus is conditioned by the preceding consonant and is a result of place assimilation to labial or dorsal consonants. Chengde is different in this respect from Wuhan but similar to Linfen, i.e., [u] in the nucleus is freely distributed. [u] is also found in the coda and the onset.

(18) [u] is found in the coda in Chengde

	/əO/	/aO/	/EəO/	/EaO/
p		paw		pʲaw
p'		p'aw		pʲ'aw
m	mow	maw		mʲaw
f	fow			
t	tow	taw	tʲow	tʲaw
t'	t'ow	t'aw		tʲ'aw
n		naw	nʲow	nʲaw
l	low	law	lʲow	lʲaw
ʦ	ʦow	ʦaw		
ts'	ts'ow	ts'aw		
s	sow	saw		
ʈʂ	ʈʂow	ʈʂaw		
ʈʂ'	ʈʂ'ow	ʈʂ'aw		
ʂ	ʂow	ʂaw		
ʐ	ʐow	ʐaw		
k	kow	kaw	ʨow	ʨaw
k'	k'ow	k'aw	ʨ'ow	ʨ'aw
ŋ	ŋow	ŋaw		
x	xow	xaw	ɕow	ɕaw
0	ow		jow	jaw

[shaded] systematic gaps

(19) [u] is found in the onset in Chengde

	/Oə/	/Oa/	/OəE/	/OaE/	/Oən/	/Oəŋ/	/Oan/	/Oaŋ/
p								
p'								
m								
f								
t	t^{w}o		t^{w}ej		t^{w}ən	t^{w}əŋ	t^{w}an	
t'	t^w'o		t^w'ej		t^w'ən	t^w'əŋ	t^w'an	
n	n^{w}o				n^{w}ən	n^{w}əŋ	n^{w}an	
l	l^{w}o				l^{w}ən	l^{w}əŋ	l^{w}an	
ʦ	ʦ^{w}o		ʦ^{w}ej		ʦ^{w}ən	ʦ^{w}əŋ	ʦ^{w}an	
ts'	ts^w'o		ts^w'ej		ts^w'ən	ts^w'əŋ	ts^w'an	
s	s^{w}o		s^{w}ej	s^{w}aj	s^{w}ən	s^{w}əŋ	s^{w}an	
tʂ	tʂ^{w}o	tʂ^{w}a	tʂ^{w}ej	tʂ^{w}aj	tʂ^{w}ən	tʂ^{w}əŋ	tʂ^{w}an	tʂ^{w}aŋ
tʂ'	tʂ^w'o		tʂ^w'ej	tʂ^w'aj	tʂ^w'ən	tʂ^w'əŋ	tʂ^w'an	tʂ^w'aŋ
ʂ	ʂ^{w}o	ʂ^{w}a	ʂ^{w}ej	ʂ^{w}aj	ʂ^{w}ən		ʂ^{w}an	ʂ^{w}aŋ
ʐ	ʐ^{w}o		ʐ^{w}ej		ʐ^{w}ən	ʐ^{w}əŋ	ʐ^{w}an	
k	k^{w}o	k^{w}a	k^{w}ej	k^{w}aj	k^{w}ən	k^{w}əŋ	k^{w}an	k^{w}aŋ
k'	k^w'o	k^w'a	k^w'ej	k^w'aj	k^w'ən	k^w'əŋ	k^w'an	k^w'aŋ
ŋ								
x	x^{w}o	x^{w}a	x^{w}ej	x^{w}aj	x^{w}ən	x^{w}əŋ	x^{w}an	x^{w}aŋ
0	wo	wa	wej	waj	wən	wəŋ	wan	waŋ

(shaded) systematic gaps

I showed in my discussion of the vowel /ə/ that the vowel [u] causes the central /ə/ to surface as a round vowel [o], suggesting that the place feature on [u] is active in the phonology and thus is present underlyingly. So the vowel /O/ is specified with a place feature Labial.

4.1.3.4 /a/--> [a]

The fourth and last vowel is /a/, which surfaces as [a].

(20) Distribution of [a] (to be continued)

	/a/	/aE/	/aO/	/an/	/aŋ/	/Ea/	/EaO/	/Ean/	/Eaŋ/
p	pa	paj	paw	pan	paŋ		pʲaw	pʲan	
p'	p'a	p'aj	p'aw	p'an	p'aŋ		pʲ'aw	pʲ'an	
m	ma	maj	maw	man	maŋ		mʲaw	mʲan	
f	fa			fan	faŋ				
t	ta	taj	taw	tan	taŋ		tʲaw	tʲan	
t'	t'a	t'aj	t'aw	t'an	t'aŋ		tʲ'aw	tʲ'an	
n	na	naj	naw	nan	naŋ		nʲaw	nʲan	nʲaŋ
l	la	laj	law	lan	laŋ		lʲaw	lʲan	lʲaŋ
ʦ	ʦa	ʦaj	ʦaw	ʦan	ʦaŋ				
ts'	ts'a	ts'aj	ts'aw	ts'an	ts'aŋ				
s	sa	saj	saw	san	saŋ				
ʈʂ	ʈʂa	ʈʂaj	ʈʂaw	ʈʂan	ʈʂaŋ				
ʈʂ'	ʈʂ'a	ʈʂ'aj	ʈʂ'aw	ʈʂ'an	ʈʂ'aŋ				
ʂ	ʂa	ʂaj	ʂaw	ʂan	ʂaŋ				
ʐ			ʐaw	ʐan	ʐaŋ				
k	ka	kaj	kaw	kan	kaŋ	ʨa	ʨaw	ʨan	ʨaŋ
k'	k'a	k'aj	k'aw	k'an	k'aŋ	ʨ'a	ʨ'aw	ʨ'an	ʨ'aŋ
ŋ		ŋaj	ŋaw	ŋan					
x	xa	xaj	xaw	xan	xaŋ	ɕa	ɕaw	ɕan	ɕaŋ
0	a	aj			aŋ	ja	jaw	jan	jaŋ

systematic gaps

(21) Distribution of [a]

	/Oa/	/OaE/	/Oan/	/Oaŋ/
p				
p'				
m				
f				
t			t^{w}an	
t'			t^{w}'an	
n			n^{w}an	
l			l^{w}an	
ts			ts^{w}an	
ts'			ts^{w}'an	
s		s^{w}aj	s^{w}an	
tʂ	tʂ^{w}a	tʂ^{w}aj	tʂ^{w}an	tʂ^{w}aŋ
tʂ'		tʂ^{w}'aj	tʂ^{w}'an	tʂ^{w}'aŋ
ʂ	ʂ^{w}a	ʂ^{w}aj	ʂ^{w}an	ʂ^{w}aŋ
ʐ			ʐ^{w}an	
k	k^{w}a	k^{w}aj	k^{w}an	k^{w}aŋ
k'	k^{w}'a	k^{w}'aj	k^{w}'an	k^{w}'aŋ
ŋ				
x	x^{w}a	x^{w}aj	x^{w}an	x^{w}aŋ
0	wa	waj	wan	waŋ

(shaded cells) systematic gaps

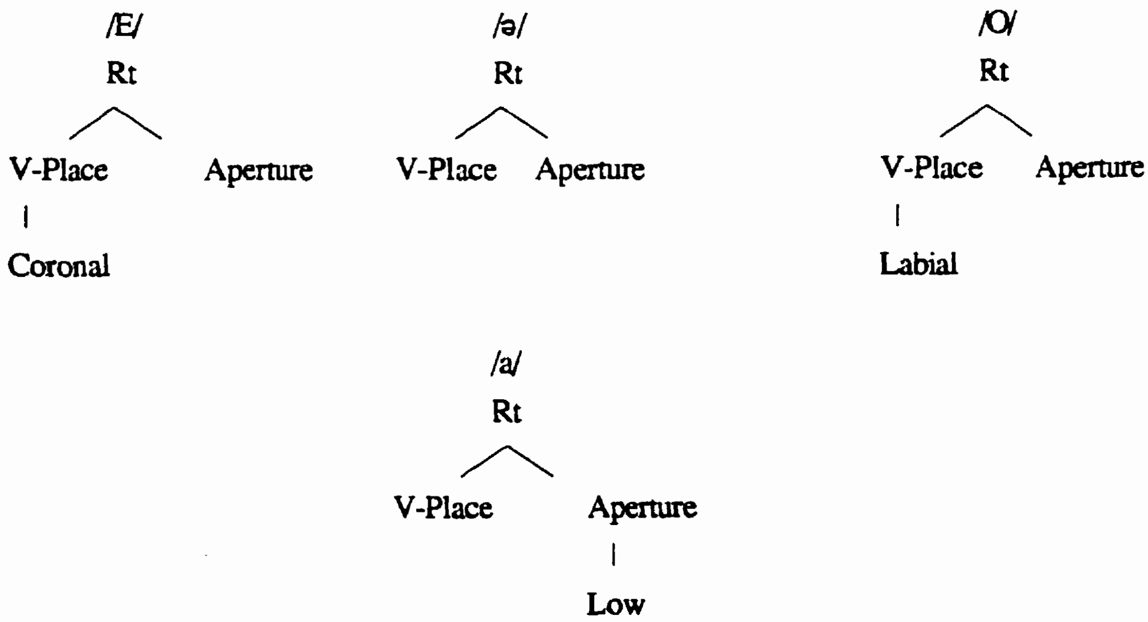
The distribution of the low vowel [a] is consistent throughout the Mandarin languages. As a central vowel, [a] never assimilates to other place features, either V-place or a C-place.

To summarize the discussion of place feature specifications of Chengde vowels, there is a three-way place contrast in the system. The phonology of the language suggests that the place features Coronal and Labial are active and so are specified on the front vowel /E/ and the back vowel /O/, respectively. The two central vowels are unspecified for place. Further, the central vowel /ə/ assimilates to the place of the other two vowels /E/ and /O/, providing evidence that the place features of the two vowels are active in the phonology.

4.1.4 Height features

Having discussed the place features, I turn to the other aspect of the feature specifications, height features. Recall that there are four vowels in the present system. I have already argued that two of them, the front vowel and the back vowel, should be specified with a place feature since their place features are active in the phonology. Thus, these two vowels, /E/ and /O/, are distinguished from the rest of the vowels in the system. There are two vowels left, /ə/ and /a/, both being central. Following our theory of minimal contrasts, these two vowels can be distinguished from each other, and from the rest of the system, by introducing the height feature Low on /a/. This would result in the following scenario regarding height, as shown below in structural representations.

(22) Proposed phonological height of vowels in Chengde



Since /E/ and /O/ are only specified for place and not for height, they are actually equivalent to the vowel /ə/ in terms of height, i.e., with a bare Aperture node. In other words in Chengde there is only a two-way height contrast.

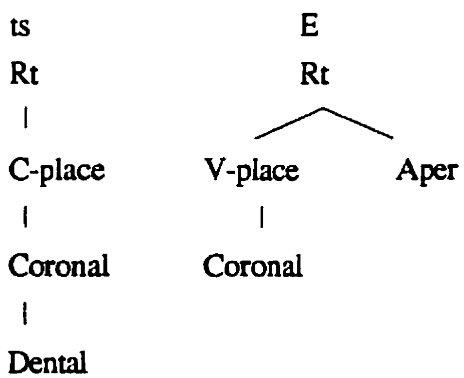
Now I show how the vowels above are realized on the surface in terms of height. In particular, since the front vowel /E/ and the back vowel /O/ are unspecified for height features owing to the lack of contrast, I show how these two vowels surface.

Following the discussion in Chapter 3, I assume that the front vowel /E/ and the back vowel /O/ surface through a default rule of High. I illustrate with examples how the two vowels surface in Chengde. First I examine /E/.

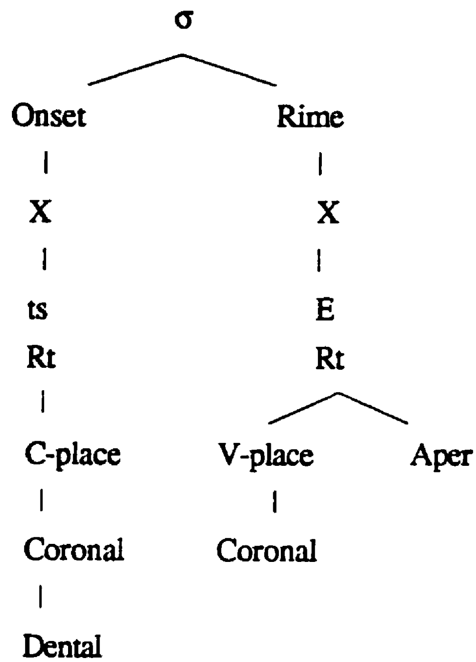
The first example is /tsE/. /E/ appears in the nucleus.

(23) How /E/ surfaces as [ɿ] after a dental consonant in Chengde

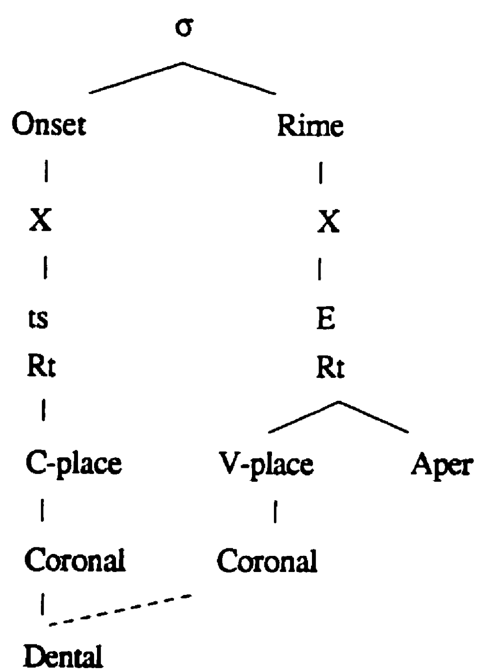
(a) Underlying /tsE/



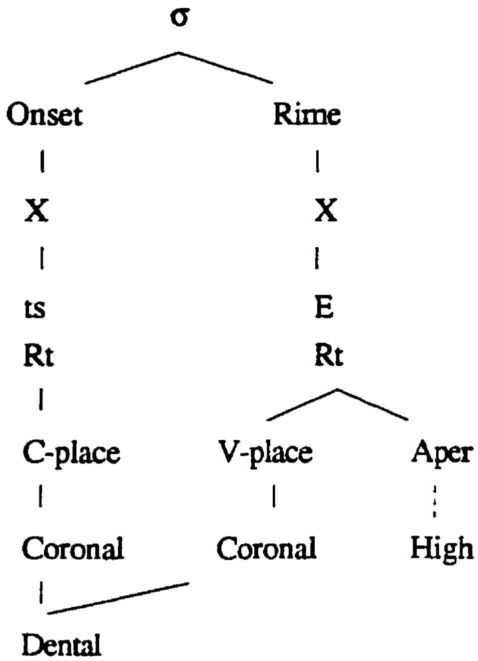
(b) After syllabification



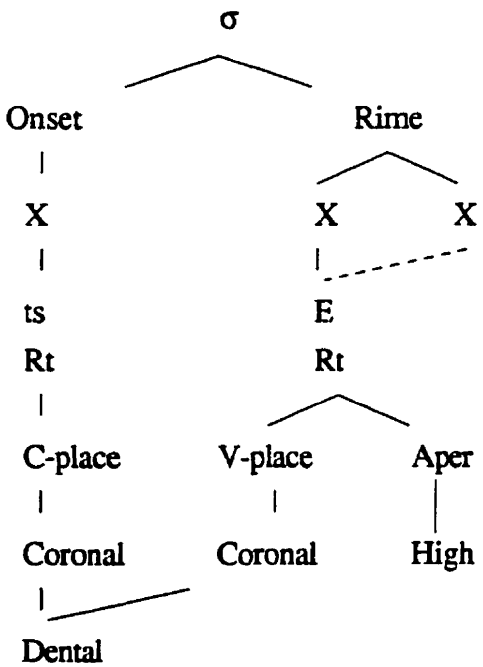
(c) Spreading



(d) Default rule of High on /E/



(e) Lengthening of /E/



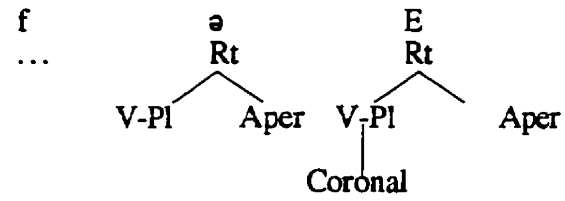
(f) Surface: [tsɿ] ("self")

After spreading in (23c), in (23d) High is inserted on /E/. In (23e) /E/ is lengthened to take both slots of the rime. Hence the surface form [tsɿ].

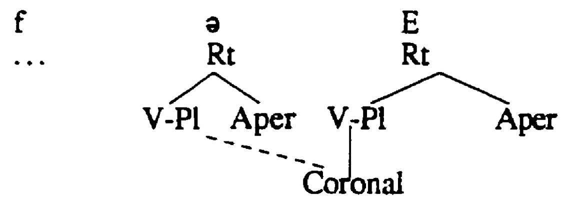
The second example is /fəE/ (surface form [fej]). /E/ appears in the coda.

(24) How /fəE/ surfaces as [fej] in Chengde

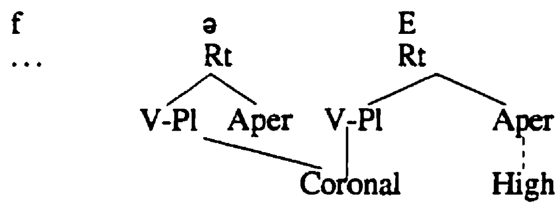
(a) Underlying



(b) Spreading from /E/ to /ə/



(c) Default High on /E/



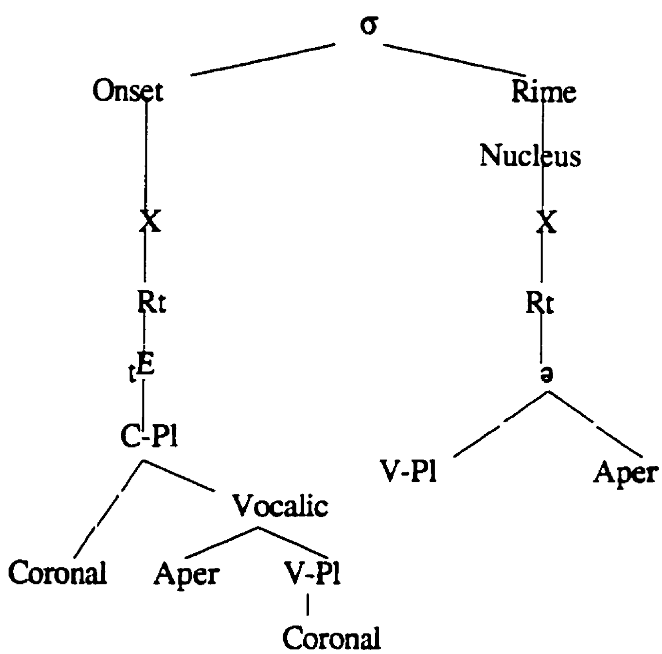
(d) Surface form: [fej] ("fly")

In (24b), Coronal is spread onto /ə/. In (24c) the default rule of High applies to /E/, but not to /ə/. I have discussed in Chapter 3 that default High cannot apply to both vowels since two surface high vowels are not allowed in Mandarin. Default High applies to the coda /E/ since the vowel in the coda position has to be a high vowel (glide) in Mandarin. Thus application of default rule High in the coda bleeds the application of the default rule in the nucleus. Hence [pej].

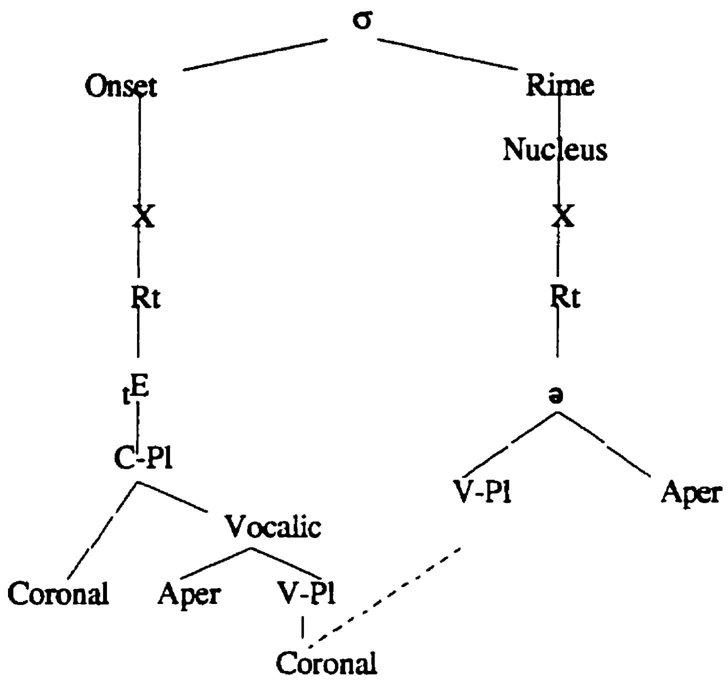
The third example is /tEə/ (surface form [tʲe]). /E/ appears in the onset position.

(25) How /tEə/ surfaces as [tʲe] in Chengde

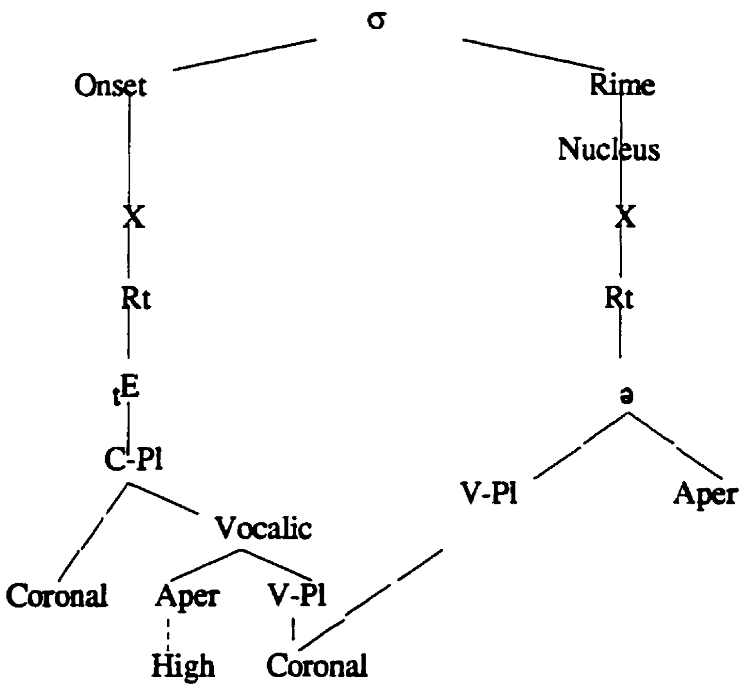
(a) Underlying after syllabification



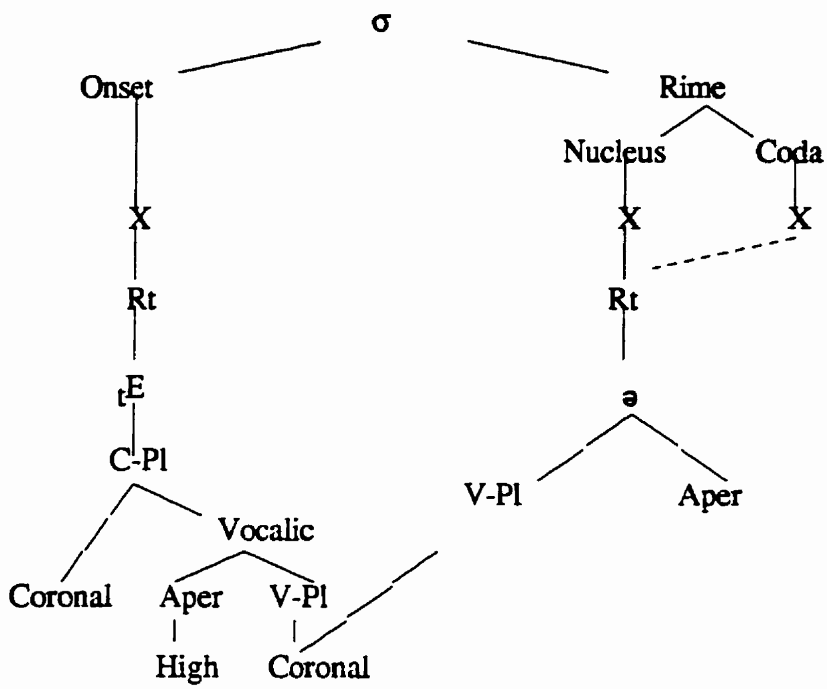
(b) Spreading from /E/ to /ə/



(c) Default High on /E/



(d) Lengthening of /ə/



(e) Surface form: [tje] ("iron")

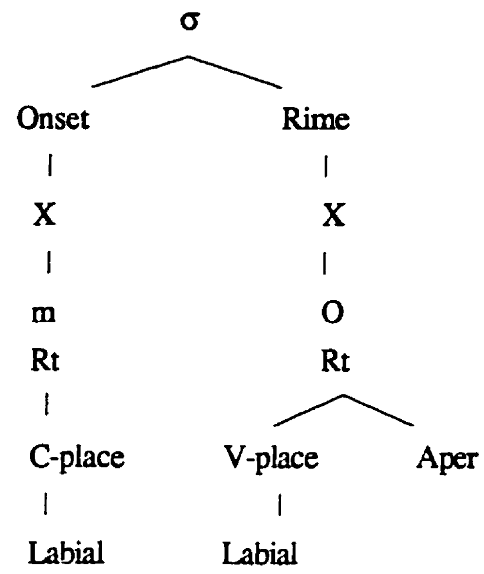
In (25b) the feature Coronal is spread onto /ə/. In (25c) High is inserted on /E/, which is in the onset, but not on /ə/, which is in the nucleus. The reason is similar as above. The vowel in the onset position has to be a high vowel (glide) in Mandarin. Further, default High cannot apply to both vowels since two consecutive surface high vowels are not allowed in Mandarin. In (25d) /ə/ is lengthened to take both slots of the rime to meet the surface bimoraicity requirement of Mandarin. Hence [tje].

Above I have shown with different examples how /E/ is realized on the surface in terms of height. Next I show with examples how /O/ is realized on the surface in terms of height.

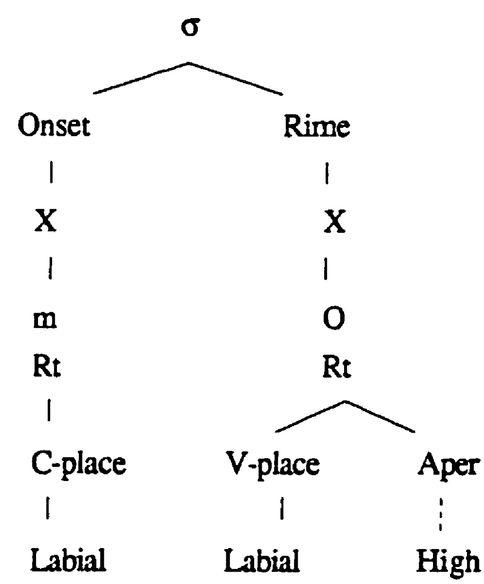
The first example is /mu/ (surface form [mu]). /O/ appears in the nucleus.

(26) How /O/ surfaces as [u] in Chengde

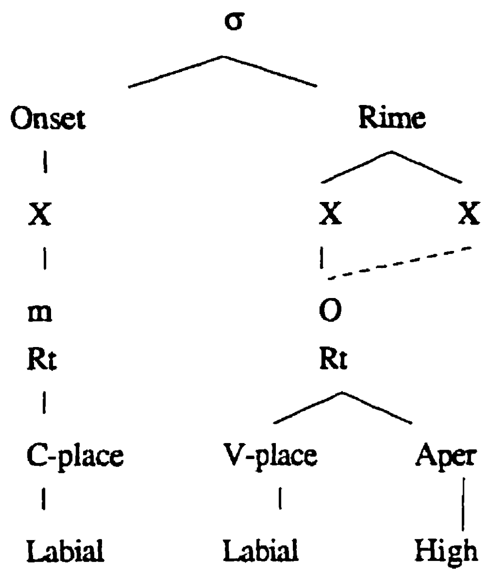
(a) Underlying



(b) Default rule of High on /O/



(c) Lengthening of /O/



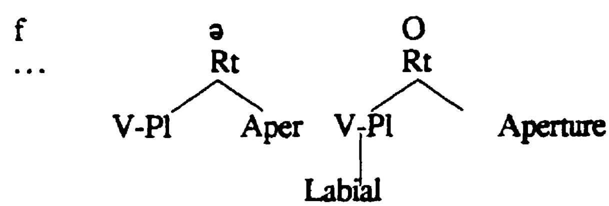
(d) Surface: [mu] ("mother")

In (26b) High is inserted on /O/. In (26c) /O/ is lengthened to take both slots of the rime. Hence the surface form [mu].

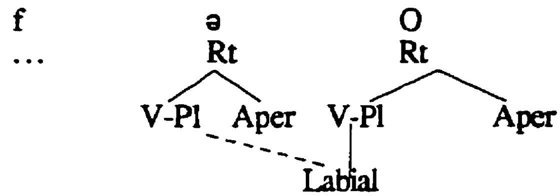
The second example is /fəO/ (surface form [fow]). /O/ appears in the coda.

(27) How /fəO/ surfaces as [fow] in Chengde

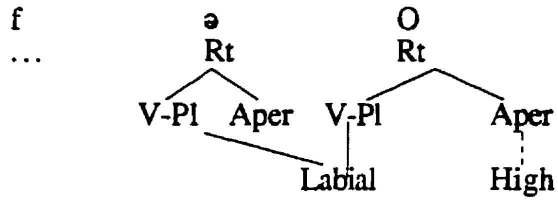
(a) Underlying



(b) Spreading from /O/ to /ə/



(c) Default High on /O/



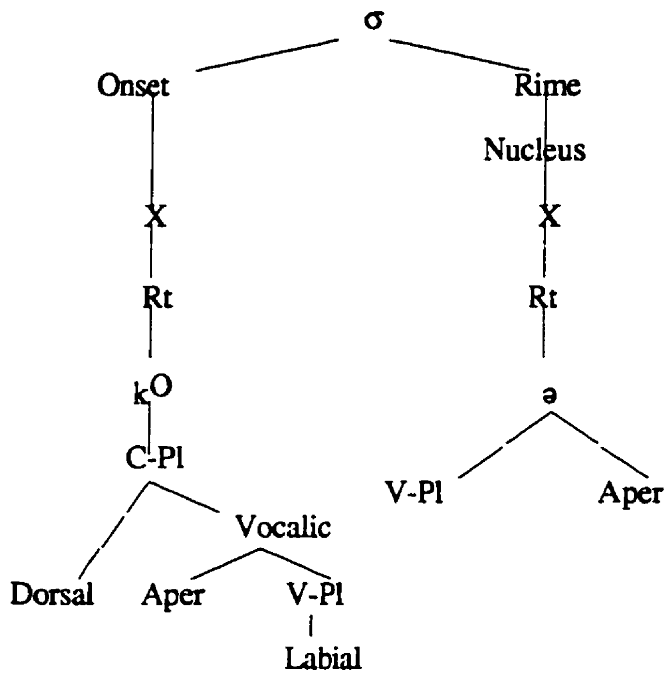
(d) Surface form: [fow] ("deny")

In (27b), Labial is spread onto /ə/. In (27c) the default rule of High applies to /O/, but not to /ə/. The reason has been given above. Hence [fow].

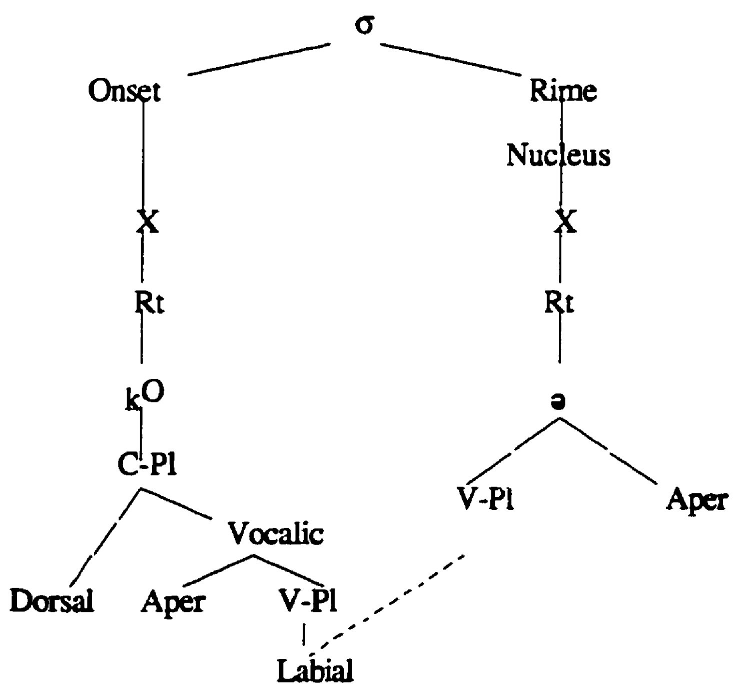
The last example of /O/ is /kOə/ (surface form [k^{w}o]). /O/ appears in the onset.

(28) How /kOə/ surfaces as [k^wo] in Chengde

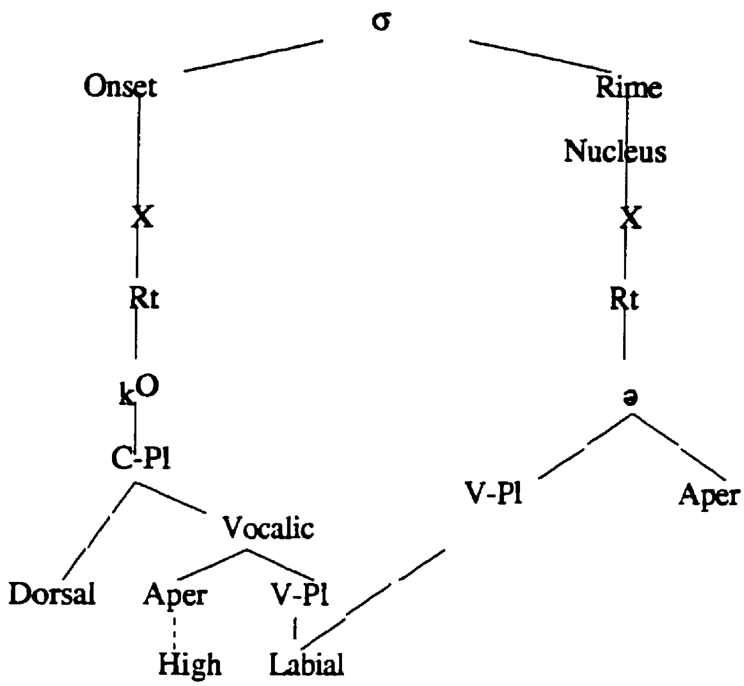
(a) Underlying



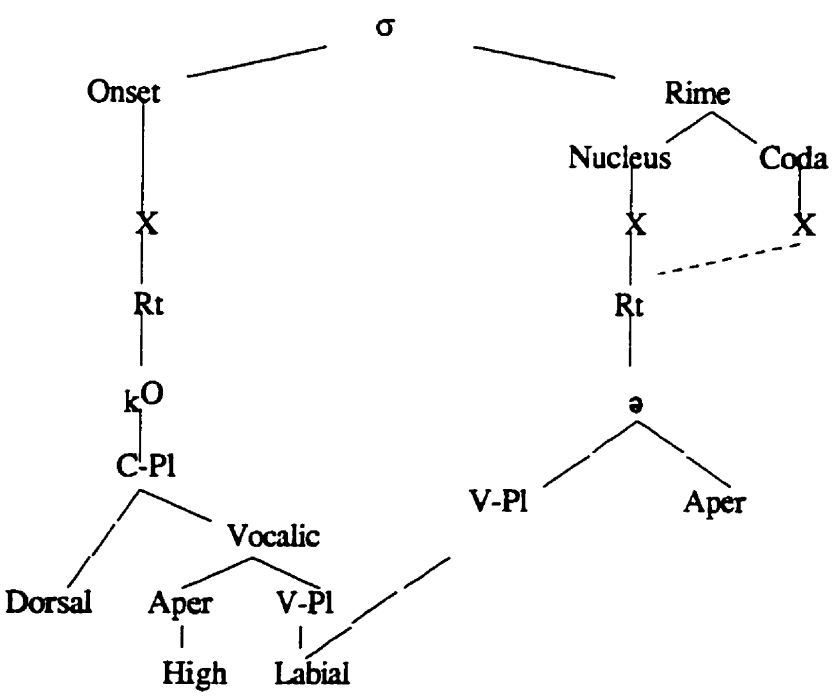
(b) Spreading from /O/ to /ə/



(c) Default High on /O/



(d) Lengthening of /ə/

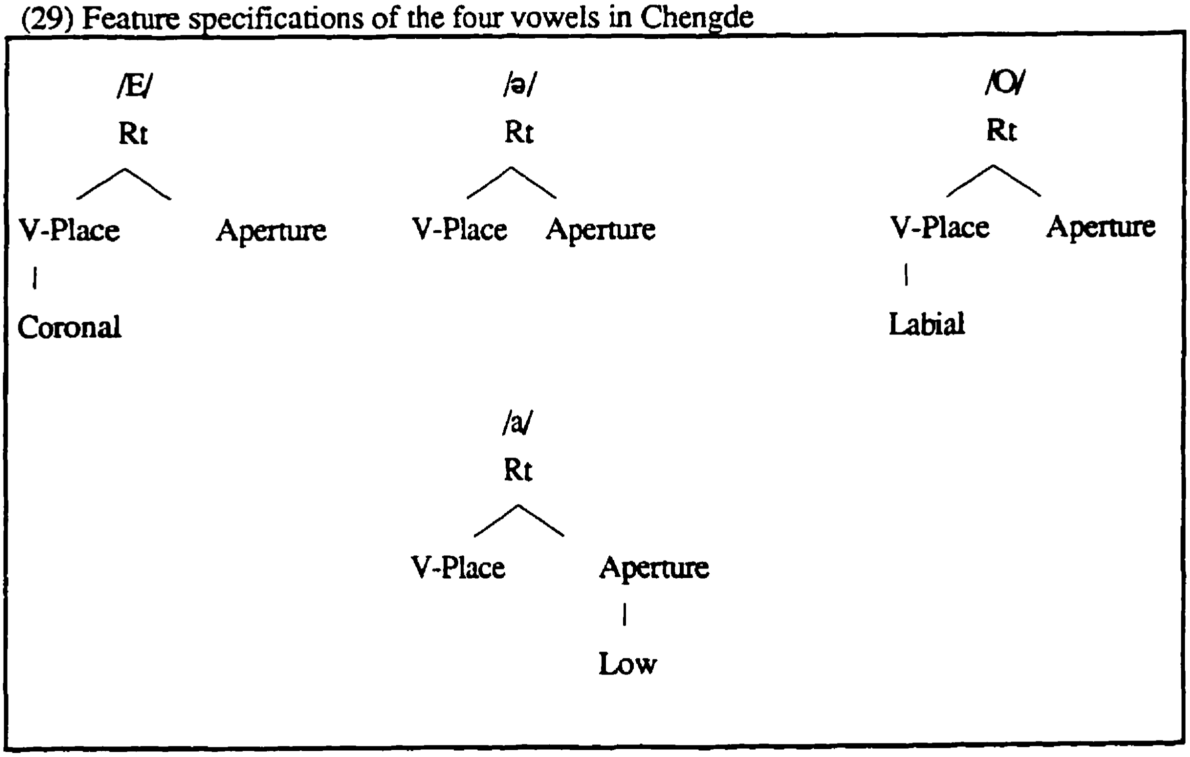


(e) Surface form: [k^wo] ("rich")

In (28b) the feature Labial is spread onto /ə/. In (28c) High is inserted on /O/, which is in the onset, but not on /ə/, which is in the nucleus. The reason is similar as discussed above. In (28d) /ə/ is lengthened to take both slots of the rime. Hence [$k^{w}o$].

To summarize, I have shown in detail how the two non-low vowels /E/ and /O/ are realized as high vowels on the surface while the third non-low vowel [ə] is realized as a mid vowel. Below is a summary of the feature specifications of the four vowels in Chengde.

(29) Feature specifications of the four vowels in Chengde



Chengde presents strong confirmation for the contrastive specification approach outlined in Chapter 2. Given that there are three phonological vowels at one height, this theory predicts that two of the three vowels, /E/ and /O/, would be active with respect to place of articulation phonology. This prediction is borne out in that both the surface vowel [i] (from

/E/) and the surface vowel [u] (from /O/) are an assimilation trigger in the language (see section 4.1.3.1).

4.2 Harbin

The second type of four-vowel inventory I examine in this chapter includes languages such as Harbin, Qiqihar, Heihe, Jiamusi, Baicheng, Changchun, Tonghua, Shenyang, Chifeng, Linhe, Taiyuan, Dalian. I take Harbin as an example. Data in Harbin come from Chen and Li 1996.

4.2.1 Consonants

First I introduce the consonant system of Harbin. (31) is the surface consonant inventory.

(30) Surface consonant inventory of Harbin

		Labial	Alveolar	Dental	Retroflex	Palatal	Velar
Stops and affricates	-asp	p	t	ts	tʂ	tɕ	k
	+asp	p'	t'	ts'	tʂ'	tɕ'	k'
Fricatives		f, v		s	ʂ, ʐ	ɕ	x
Sonorants		m	n, l				ŋ

This inventory is very close to the one in Chengde. There are six types of place of articulation, including both dentals and retroflexes. There are only a few minor differences, such as the contrast between voiced vs. voiceless labial fricative ([f] vs. [v]), which exists in Harbin but not in Chengde.

Assuming that surface palatals in the above table are not underlying consonants but surface realizations of palatalized velars, I propose the following phonological consonant inventory of Harbin.

(31) Phonological inventory

		Labial	Alveolar	Dental	Retroflex	Velar
Stops and affricates	-asp	p	t	ts	ʈʂ	k
	+asp	p'	t'	ts'	ʈʂ'	k'
Fricatives		f, v		s	ʂ	x
Sonorants		m	n, l		ʐ	ŋ

The place feature specifications of each type of consonant above have been discussed in Chapter 2 and are not repeated. Next I examine the vowel system.

4.2.2 Vowel inventory: phonetic

First I present the surface vowel inventory of Harbin.

(32) Surface vowel inventory of Harbin

	Front		Central	Back	
	Unrounded	Rounded	Unrounded	Unrounded	Rounded
High	i	ü	ɿ	ʅ	u
Mid	e		ɤ (tense) ə (lax)		
Low			a		

The above inventory differs from Chengde (see table 3) in that the back rounded vowel [o] is not found in the Harbin inventory. This results from the different distributional patterns of the vowels in the two languages, as I examine next.

I propose that the vowels in the above table are derived from the following four vowels.

(33) Proposed phonological vowel inventory

	ɨ
E	ə
	a

Further the distribution of each of the four vowels is given below.

(34) Distribution of the four vowels in Harbin

/E/ -->	[ɿ]	after a dental consonant in the nucleus
	[ʅ]	after a retroflex consonant in the nucleus
	[i]	elsewhere
/ɨ/ -->	[u]	by default
/ə/-->	[e]	following or preceding glide [j]
	[ɤ]	in open syllable but not following glide [j]
	[ə]	elsewhere
/a/ -->	[a]	

That is, /E/ surfaces as [ɿ] after a dental consonant, as [ʅ] after a retroflex consonant, and as [i] elsewhere. This pattern resembles all the other Mandarin languages. The vowel /ɨ/ is placeless and surfaces as [u] by the default rule of labial insertion, as in Linfen (section 3.2.3.2). I will show in section 4.2.3 why the vowel /ɨ/ lacks place specification underlyingly and requires a default rule providing a specified place of articulation for it to surface. The vowel /ə/ has three different variants depending on the environments. [e] occurs either following or preceding glide [j]. [ɤ] occurs in open syllable but not following glide [j]. [ə] occurs in environments other than those. Notice that unlike Chengde, /ə/ does not have a fourth variant [o]. I will address this difference in section 4.2.3.1. Finally the vowel /a/ surfaces as [a] as in all other Mandarin languages.

Next I examine the distribution of each vowel, with a focus on the feature specifications each vowel carries. I examine the place features first. I assume height features represented as in (33), with /ɨ/ being high, /E/ and /ə/ being mid, and /a/ being low. Further I assume the following place feature specifications in structural representations.

(35) place feature specifications of the four vowels in Harbin

/E/	/ɨ/, /ə/, /a/
Rt	Rt
|	|
V-Place	V-Place
|	
Coronal	

As for Chengde, I first discuss the vowel /ə/, since the place feature specifications of two other vowels, /E/ and /ɨ/, depend on the behavior of this vowel.

4.2.3 Place features

4.2.3.1 /ə/ --> [e], [ɤ], [ə]

The three surface variants of /ə/ occur in complementary distribution, as presented below.

(36) Where [e] is found in Harbin: preceding or following glide [j]

	/əE/	/ɨəE/	/Eə/	/ɨEə/
p	pej		p^{j}e	
p'	p'ej		p^{j}'e	
m	mej		m^{j}e	
f	fej			
v	vej			
t	tej	t^{w}ej	t^{j}e	
t'	t'ej	t^{w}'ej	t^{j}'e	
n	nej		n^{j}e	n^{ɥ}e
l	lej		l^{j}e	l^{ɥ}e
ʦ	ʦej	ʦ^{w}ej		
ts'		ts^{w}'ej		
s	sej	s^{w}ej		
tʂ		tʂ^{w}ej		
tʂ'		tʂ^{w}'ej		
ʂ	ʂej	ʂ^{w}ej		
ʐ		ʐ^{w}ej		
k	kej	k^{w}ej	tɕe	tɕ^{w}e
k'	k'ej	k^{w}'ej	tɕ'e	tɕ^{w}'e
ŋ				
x	xej	x^{w}ej	ɕe	ɕ^{w}e
0			je	ɥe

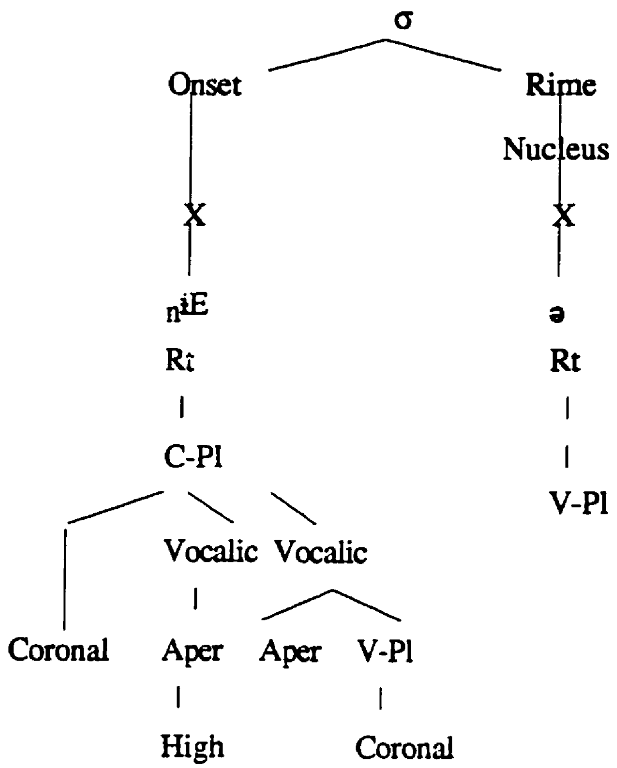
[shaded box] systematic gaps

The surface form [e] is found only next to the glide [j]. In other words the existence of [e] is conditioned by the appearance [j]. This can be viewed as a result of assimilation between the two segments. More specifically the glide [j], a front vowel itself, causes [e] to be fronted. I do not repeat the assimilation process.

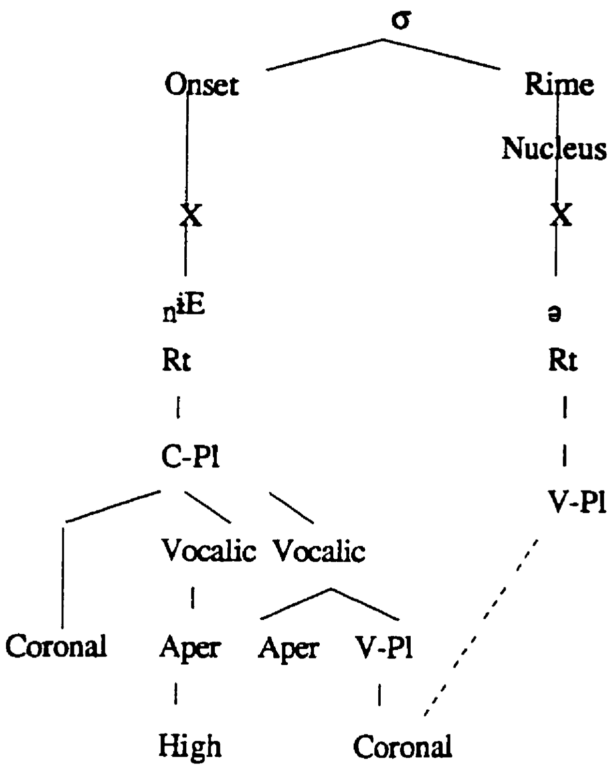
I address the sequence /ɨEə/ in the above table. I take [n^{ɥ}e] (underlyingly /nɨiə/) as an example to show the derivations of this sequence.

(37) How /niEə/ is realized as [nᶣe] (ignoring height features)

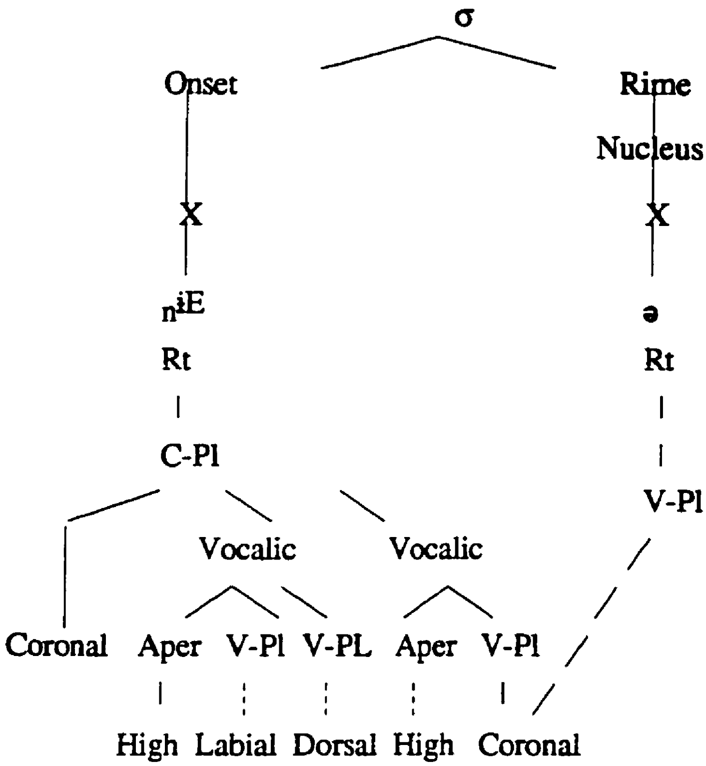
(a) After syllabification



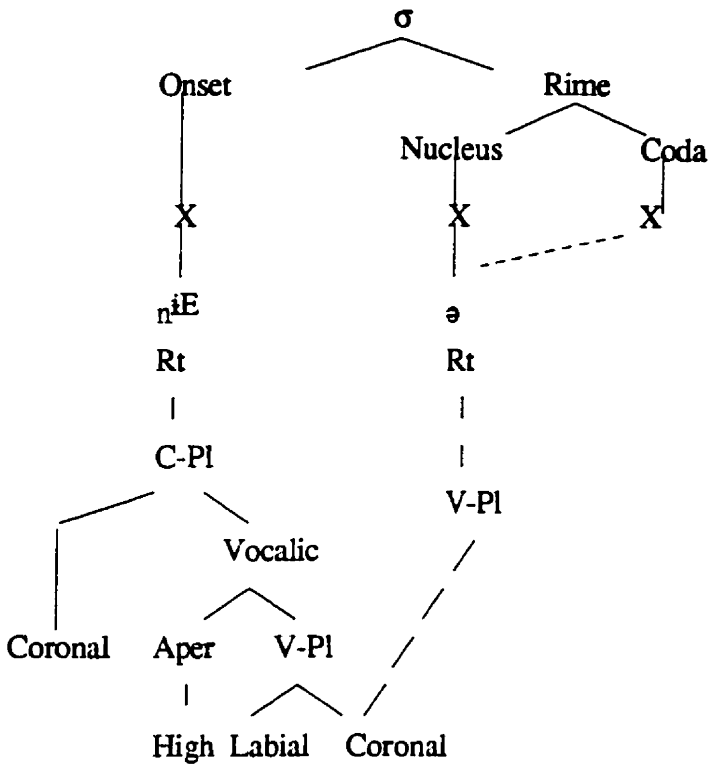
(b) Spreading Coronal onto /ə/



(c) Default Labial and Dorsal on /ɨ/ and default High on /E/



(d) Coalescence of /ɨ/ and /E/ and lengthening of /ə/



(e) Surface: [n$^{\text{ɥ}}$e] ("malaria")

After spreading in (37b), in (37c) default rules of Labial and Dorsal apply to /ɨ/ and default rule of High applies to /E/. In (37d) /ɨ/ and /E/ coalesce as [ü] ([ɥ] as a glide), and /ə/ is lengthened to take both slots of the rime. Hence [n$^{\text{ɥ}}$e].

The second surface variant of /ə/ is [ɤ]. Its distribution is given below.

(38) Where [ɤ] is found in Harbin: in open syllable but not following glide [j]

	/ə/	/ʷə/
p	pɤ	
p'	p'ɤ	
m	mɤ	
f	fɤ	
v	vɤ	
t	tɤ	tʷɤ
t'	t'ɤ	tʷ'ɤ
n	nɤ	nʷɤ
l	lɤ	lʷɤ
ts	tsɤ	tsʷɤ
ts'	ts'ɤ	tsʷ'ɤ
s	sɤ	sʷɤ
tʂ	tʂɤ	tʂʷɤ
tʂ'	tʂ'ɤ	tʂʷ'ɤ
ʂ	ʂɤ	ʂʷɤ
ʐ	ʐɤ	
k	kɤ	kʷɤ
k'	k'ɤ	kʷ'ɤ
x	xɤ	xʷɤ
0	ɤ	

systematic gaps

The surface form [ɤ] is found in an open syllable. This is not strange to us, as the same pattern has been seen in the other languages discussed in this thesis. Recall that [ɤ] is a result of lengthening /ə/ on the surface, driven by the syllable structure requirement of Mandarin languages in general. More specifically, /ə/, the only segment in the rime (open syllable), is lengthened so as to take up both slots of the rime. The process of lengthening has been shown for the language Wuhan and is not repeated here.

In the above table the sequence /ʷə/ surfaces as [ʷɤ]. This can be compared with another sequence that has been discussed, /ʲə/, which surfaces as [ʲe] (see table 37). In both cases /ə/ is preceded by a glide. While glide [j] causes /ə/ to be fronted on the surface as [e], glide

[w] does not affect /ə/ in this respect and /ə/ is lengthened in the same way as in a /Cə/ sequence. This suggests that while the place feature on [j] is active in Harbin, the place feature on [w] is not. This difference between [j] and [w] will be seen again next when I examine the third variant of /ə/.

The third variant of /ə/ is [ə]. The distribution is given below.

(39) Where [ə] is found in Harbin: elsewhere

	/ən/	/əŋ/	/əɨ/	/iən/	/iəŋ/	/Eəɨ/	/Eən/	/Eəŋ/	/iEən/	/iEəŋ/
p	pən	pəŋ					pʲən	pʲəŋ		
p'	p'ən	p'əŋ					pʲ'ən	pʲ'əŋ		
m	mən	məŋ					mʲən	mʲəŋ		
f	fən	fəŋ								
v		vəŋ								
t	tən	təŋ	təw	tʷən	tʷəŋ	tʲəw		tʲəŋ		
t'	t'ən	t'əŋ	t'əw	tʷ'ən	tʷ'əŋ			tʲ'əŋ		
n	nən	nəŋ	nəw			nʲəw	nʲən	nʲəŋ		
l	lən	ləŋ	ləw	lʷən		lʲəw	lʲən	lʲəŋ		
ts	tsən	tsəŋ	tsəw	tsʷən	tsʷəŋ					
ts'			ts'əw	tsʷ'ən	tsʷ'əŋ					
s	sən	səŋ	səw	sʷən	sʷəŋ					
tʂ	tʂən	tʂəŋ	tʂəw	tʂʷən	tʂʷəŋ					
tʂ'	tʂ'ən	tʂ'əŋ	tʂ'əw	tʂʷ'ən	tʂʷ'əŋ					
ʂ	ʂən	ʂəŋ	ʂəw							
ʐ	ʐən	ʐəŋ	ʐəw							
k	kən	kəŋ	kəw	kʷən	kʷəŋ	tɕəw	tɕən	tɕəŋ	tɕʷən	tɕʷəŋ
k'	k'ən	k'əŋ	k'əw	kʷ'ən	kʷ'əŋ	tɕ'əw	tɕ'ən	tɕ'əŋ	tɕʷ'ən	tɕʷ'əŋ
ŋ	ŋən		ŋəw							
x	xən	xəŋ	xəw	xʷən	xʷəŋ	ɕəw	ɕən	ɕəŋ	ɕʷən	ɕʷəŋ
0				wən	wən	jəw	jən	jəŋ	ɥən	ɥəŋ

[shaded] systematic gaps

The surface form [ə] is found in environments other than those for [e] and [ɤ]. That is, [ə] is found in a closed syllable, followed by either a nasal, [n] or [ŋ], or glide [w]. In such an environment, /ə/ is not lengthened (unlike [ɤ]), since it occurs in a closed syllable and both positions of the rime are occupied, nor does /ə/ assimilate to a neighbouring segment, though for different reasons. When the neighbouring segment is a nasal, /ə/ fails to assimilate since it only assimilates to a vowel, not a consonant, as has already been discussed.

When the neighbouring segment is [w], /ə/ does not assimilate either. For instance, in the sequence /əw/, no assimilation happens. The sequence surfaces as [əw]. This can be compared with the sequence /əj/. When /ə/ is followed by glide [j], [j] causes /ə/ to be fronted as [e], giving [ej] (see table 36). This indicates that the place feature on [j] is active in Harbin whereas the place feature on [w] is inert. Recall that above I have mentioned a parallel situation. When /ə/ is preceded by glide [j] or [w], it becomes fronted because of [j] but not rounded because of [w]. Hence the surface sequences [ʲe] vs. [ʷə]. Based on these differences between [j] and [w] in their ability to affect a neighbouring /ə/, I conclude that the place feature Coronal is underlyingly present on [j] whereas the place feature Labial is underlyingly absent on [w].

Another point I address in (39) is sequences such as [ʲəw], [ʲən], and [ʲəŋ]. Recall that in Mandarin the target of spreading must c-command the trigger. There are two potential triggers both c-commanding /ə/ in these sequences. I have already discussed that the target /ə/ c-commands either a nasal or a glide [w] in these cases. We know that /ə/ does not assimilate to a nasal (consonant), and glide [w] is unspecified for place feature underlyingly. Hence no assimilation in these cases.

To summarize the discussions on /ə/ in Harbin, this vowel surfaces as three variants depending on the environment. /ə/ assimilates in place to the glide [j] but not [w], suggesting that the place feature Coronal is active and underlyingly present on [j] but the place feature Labial is inert and thus underlyingly absent on [w]. Further, there are two assimilation constraints on /ə/, which are identical to the constraints required in the other three Mandarin languages Wuhan, Linfen, and Chengde.

4.2.3.2 /E/ --> [ɿ], [ʅ], [i]

The vowel /E/ surfaces as [ɿ] after a dental consonant, as [ʅ] after a retroflex consonant, and as [i] elsewhere. This pattern has been seen repeatedly in the other three languages that have been examined. I show the distributions of each variant in Harbin.

(40) Where [ɿ] is found in Harbin: in the nucleus after a dental consonant

	/E/
p	
p'	
m	
f	
v	
t	
t'	
n	
l	
ts	tsɿ
ts'	ts'ɿ
s	sɿ
tʂ	
tʂ'	
ʂ	
ʐ	
k	
k'	
ŋ	
x	
0	

The form [ɿ] is only found in the nucleus and following a dental consonant.

(41) Where [ʅ] is found in Harbin: in the nucleus after a retroflex consonant

	/E/
p	
p'	
m	
f	
v	
t	
t'	
n	
l	
ts	
ts'	
s	
tʂ	tʂʅ
tʂ'	tʂ'ʅ
ʂ	ʂʅ
ʐ	ʐʅ
k	
k'	
ŋ	
x	
0	

The form [ʅ] is only found in the nucleus following a retroflex consonant. The two forms [ɿ] and [ʅ] form a complementary distribution with the third vowel [i], as shown below.

(42) [i] appears in the nucleus in Harbin

	/E/
p	pi
p'	p'i
m	mi
f	
v	
t	ti
t'	t'i
n	ni
l	li
ts	
ts'	
s	
tʂ	
tʂ'	
ʂ	
ʐ	
k	tɕi
k'	tɕ'i
ŋ	
x	ɕi
0	i

When [i] appears in the nucleus, it follows consonants other than dentals or retroflexes. [i] also appears in the coda and onset, as shown in the following two tables.

(43) [i] appears in the coda in Harbin

	/əE/	/aE/	/uəE/	/uaE/
p		paj		
p'		p'aj		
m		maj		
f				
v		vaj		
t	tej	taj	tʷej	
t'	t'ej	t'aj	tʷ'ej	
n		naj		
l		laj		
ʦ	ʦej	ʦaj	ʦʷej	
ts'	ts'ej	ts'aj	tsʷ'ej	
s	sej	saj	sʷej	
tʂ	tʂej	tʂaj	tʂʷej	tʂʷaj
tʂ'	tʂ'ej	tʂ'aj	tʂʷ'ej	tʂʷ'aj
ʂ	ʂej	ʂaj	ʂʷej	ʂʷaj
ʐ	rej		ʐʷej	
k	kej	kaj	kʷej	kʷaj
k'	k'ej	k'aj	kʷ'ej	kʷ'aj
ŋ				
x	xej	xaj	xʷej	xʷaj
0		aj		

(shaded box) systematic gaps

(44) [i] appears in the onset in Harbin

	/Ea/	/Eə/	/Eai/	/Eəi/	/Ean/	/Eən/	/Eaŋ/	/Eəŋ/
p		pʲe	pʲaw		pʲan	pʲən		pʲəŋ
p'		pʲ'e	pʲ'aw		pʲ'an	pʲ'ən		pʲ'əŋ
m		mʲe	mʲaw		mʲan	mʲən		mʲəŋ
f								
v								
t		tʲe	tʲaw	tʲəw	tʲan			tʲəŋ
t'		tʲ'e	tʲ'aw		tʲ'an			tʲ'əŋ
n		nʲe		nʲəw	nʲan	nʲən	nʲaŋ	nʲəŋ
l	lʲa	lʲe	lʲaw	lʲəw	lʲan	lʲən	lʲaŋ	lʲəŋ
ts								
ts'								
s								
ʈʂ								
ʈʂ'								
ʂ								
ʐ								
k	tɕa	tɕe	tɕaw	tɕəw	tɕan	tɕən	tɕaŋ	tɕəŋ
k'	tɕ'a	tɕ'e	tɕ'aw	tɕ'əw	tɕ'an	tɕ'ən	tɕ'aŋ	tɕ'əŋ
ŋ								
x		ɕe	ɕaw	ɕəw	ɕan	ɕən	ɕaŋ	ɕəŋ
0	ja	je	jaw	jəw	jan	jən	jaŋ	jəŋ

(shaded) systematic gaps

Based on the complementary distribution of the three surface vowels [ɿ], [ʅ], and [i], I propose that they form one phoneme /E/ (given that [i] is the form with the widest distribution). The two variants [ɿ] and [ʅ] are derived through place assimilation to the preceding consonant, as I have shown for the other three languages. I do not repeat the process here. The vowel /E/ is specified with a place feature Coronal, as we saw earlier that the place feature on /E/ is active in the phonology in that /E/ causes a neighbouring /ə/ to be fronted on the surface.

That the feature Coronal is present on /E/ underlyingly is supported not only by the distributional patterns of /E/, but also by the diminutive r-suffixation in the language. The r-suffixation patterns in Harbin are similar to Linfen and Chengde. That is, /E/ patterns in the same way as /n/ (specified with place feature Coronal) in that both resist being adjacent to another coronal segment /r/. This suggests that the place feature Coronal must be present underlyingly on /E/. I have presented the details for Linfen (section 3.2.3.3 of Chapter 3) and do not repeat them here.

4.2.3.3 /ɨ/ --> [u]

The third phonological vowel I propose for Harbin is /ɨ/, which relates to the surface form [u]. I show the distribution of [u] in (45).

(45) Distribution of [u]

a) [u] in Nucleus b) [u] in the Onset c) [u] in the Coda

	/ɨ/	/ɨa/	/ɨə/	/ɨaE/	/ɨəE/	/ɨan/	/ɨən/	/ɨaŋ/	/ɨəŋ/	/əɨ/	/Eəɨ/	/Eaɨ/
p	pu											pʲaw
p'	p'u											pʲ'aw
m	mu											mʲaw
f	fu											
v	vu											
t	tu		tʷɤ		tʷej	tʷan	tʷən		tʷəŋ	təw	tʲəw	tʲaw
t'	t'u		tʷ'ɤ		tʷ'ej	tʷ'an	tʷ'ən		tʷ'əŋ	t'əw		tʲ'aw
n	nu		nʷɤ							nəw	nʲəw	
l	lu		lʷɤ				lʷən			ləw	lʲəw	lʲaw
ʦ	ʦu	ʦʷa	ʦʷɤ		ʦʷej	ʦʷan	ʦʷən		ʦʷəŋ	ʦəw		
ts'	ts'u		tsʷ'ɤ		tsʷ'ej	tsʷ'an	tsʷ'ən		tsʷ'əŋ	ts'əw		
s	su	sʷa	sʷɤ		sʷej	sʷan	sʷən		sʷəŋ	səw		
ʈʂ	ʈʂu	ʈʂʷa	ʈʂʷɤ	ʈʂʷaj	ʈʂʷej	ʈʂʷan	ʈʂʷən	ʈʂʷaŋ	ʈʂʷəŋ	ʈʂəw		
ʈʂ'	ʈʂ'u		ʈʂʷ'ɤ	ʈʂʷ'aj	ʈʂʷ'ej	ʈʂʷ'an	ʈʂʷ'ən	ʈʂʷ'aŋ	ʈʂʷ'əŋ	ʈʂ'əw		
ʂ	ʂu	ʂʷa	ʂʷɤ	ʂʷaj	ʂʷej	ʂʷan		ʂʷaŋ		ʂəw		
ʐ	ʐu				ʐʷej	ʐʷan				ʐəw		
k	ku	kʷa	kʷɤ	kʷaj	kʷej	kʷan	kʷən	kʷaŋ	kʷəŋ	kəw	ʨəw	ʨaw
k'	k'u	kʷ'a	kʷ'ɤ	kʷ'aj	kʷ'ej	kʷ'an	kʷ'ən	kʷ'aŋ	kʷ'əŋ	k'əw	ʨ'əw	ʨ'aw
ŋ										ŋəw		
x	xu	xʷa	xʷɤ	xʷaj	xʷej	xʷan	xʷən	xʷaŋ	xʷəŋ	xəw	ɕəw	ɕaw
0							wən		wən		jəw	jaw

[shaded box] systematic gaps

The vowel [u] appears in the nucleus, the onset, and the coda. As I have discussed above, unlike the other vowel [i], [u] does not affect the place feature of a neighbouring schwa (see sequences [ʷə], [əw], [ʲəw]). Given that the place feature of [u] is inert in the language, I propose that [u] is underlyingly unspecified for a place feature, which is equivalent to /ɨ/. /ɨ/ surfaces by a default rule of Labial insertion.

4.2.3.4 /a/ --> [a]

Lastly is the vowel /a/, which always surfaces as [a].

(46) Distribution of [a] (to be continued)

	/a/	/aE/	/ai/	/an/	/aŋ/	/Ea/	/Eai/	/Ean/	/Eaŋ/
p	pa	paj	paw	pan	paŋ		pʲau	pʲan	
p'	p'a	p'aj	p'aw	p'an	p'aŋ		pʲ'au	pʲ'an	
m	ma	maj	maw	man	maŋ		mʲau	mʲan	
f	fa			fan	faŋ				
v	va	vaj		van	vaŋ				
t	ta	taj	taw	tan	taŋ		tʲau	tʲan	
t'	t'a	t'aj	t'aw	t'an	t'aŋ		tʲ'au	tʲ'an	
n	na	naj	naw	nan	naŋ			nʲan	nʲaŋ
l	la	laj	law	lan	laŋ	lʲa	lʲau	lʲan	lʲaŋ
ʦ	ʦa	ʦaj	ʦaw	ʦan	ʦaŋ	░	░	░	░
ts'		ts'aj	ts'aw	ts'an	ts'aŋ	░	░	░	░
s		saj	saw	san	saŋ	░	░	░	░
ʈʂ	ʈʂa	ʈʂaj	ʈʂaw	ʈʂan	ʈʂaŋ	░	░	░	░
ʈʂ'		ʈʂ'aj	ʈʂ'aw	ʈʂ'an	ʈʂ'aŋ	░	░	░	░
ʂ		ʂaj	ʂaw	ʂan	ʂaŋ	░	░	░	░
ʐ			ʐaw	ʐan	ʐaŋ	░	░	░	░
k	ka	kaj	kaw	kan	kaŋ	ʨa	ʨau	ʨan	ʨaŋ
k'	k'a	k'aj	k'aw	k'an	k'aŋ	ʨ'a	ʨ'au	ʨ'an	ʨ'aŋ
ŋ									
x	xa	xaj	xaw	xan	xaŋ		ɕau	ɕan	ɕaŋ
0	a	aj	aw	an	aŋ	ja	jau	jan	jaŋ

░ systematic gaps

(46) Distribution of [a] (continued)

	/ia/	/iaE/	/ian/	/iaŋ/	/iEan/
p					
p'					
m					
f					
v					
t			t^{w}an		
t'			t^{w}'an		
n					
l					
ʦ	$ʦ^{w}$a		$ʦ^{w}$an		
ts'			ts^{w}'an		
s	s^{w}a		s^{w}an		
tʂ	$tʂ^{w}$a	$tʂ^{w}$aj	$tʂ^{w}$an	$tʂ^{w}$aŋ	
tʂ'		$tʂ^{w}$'aj	$tʂ^{w}$'an	$tʂ^{w}$'aŋ	
ʂ	$ʂ^{w}$a	$ʂ^{w}$aj	$ʂ^{w}$an	$ʂ^{w}$aŋ	
ʐ			$ʐ^{w}$an		
k	k^{w}a	k^{w}aj	k^{w}an	k^{w}aŋ	$ʨ^{w}$an
k'	k^{w}'a	k^{w}'aj	k^{w}'an	k^{w}'aŋ	$ʨ^{w}$'an
ŋ					
x	x^{w}a	x^{w}aj	x^{w}an	x^{w}aŋ	$ɕ^{w}$an
0					ɥan

[shaded box] systematic gaps

The low central vowel /a/ in Harbin patterns in the same way as /a/ in the other three languages.

To summarize, I have examined the place feature specifications of the four proposed vowels, based on both the distributional patterns and the phonological behavior of the surface vowels in the language. The place feature of the front vowel /E/, like all three other Mandarin languages I have examined, is active and so is present underlyingly. The other three vowels are unspecified for place, among which the vowel /i/ is unspecified for place as shown by the inertness of the place feature.

4.2.4 Height features

I propose the following height specifications for the 4 vowels in Harbin.

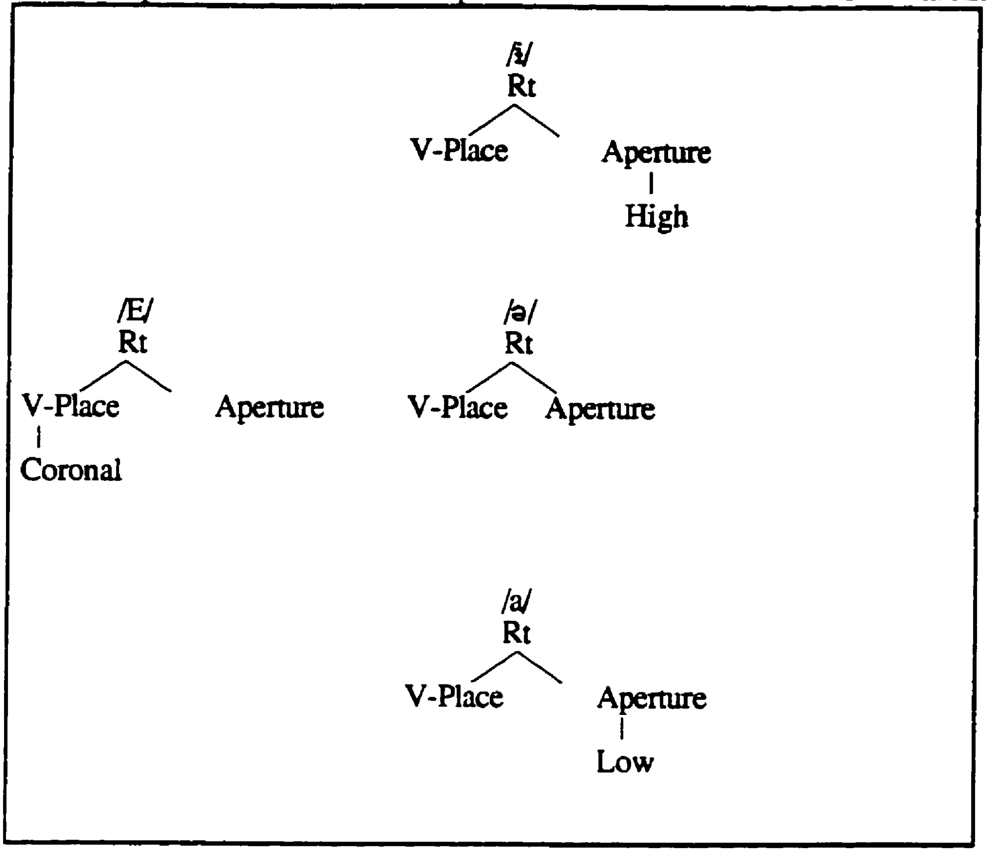
(47) Vowel inventory of Harbin

	ɨ
E	ə
	a

That is, a three-way height contrast is found for central vowels. Thus two height features are required to distinguish between them. Low is marked on /a/ and High is marked on /ɨ/. /ə/ is unspecified for both height and place. The fourth vowel /E/ is the only front vowel in the system. Since /E/ does not contrast with any other segment in terms of height, it does not have to be specified for a height feature. As we have seen, it is specified for the place feature Coronal. This distinguishes /E/ from the other three vowels. Since /E/ is unspecified for height owing to lack of contrast, it is equivalent to a mid vowel. /E/ surfaces through a default rule of High insertion. I have shown similar details of height derivations of the front vowel for Chengde and do not repeat them here.

I summarize the feature specifications of the four vowels in Harbin in structural representations.

(48) Structural representations of feature specifications of the four vowels in Harbin



4.3 Conclusion

In this chapter I have introduced two types of four-vowel Mandarin inventories. In particular the two inventories are similar in that there is a front vowel active in the phonology that causes changes in the place of a neighboring schwa. However, the two types differ in the behavior of the surface round vowel [u] in that this vowel is active in Chengde but inert in Harbin.

The languages examined in this chapter include all four-vowel-inventory languages in Chen and Li 1996. It is striking that no other four-vowel inventories are found. One could imagine various types; a few are presented schematically here:

(49)(a)

Front	Central
X	X
	X
	X

(b)

Front	Central
X	X
X	
X	

(c)

Front	Central	Back
	X	
X	X	X

(d)

Central	Back
X	X
X	
X	

Although these inventories are not found in Mandarin, it is not impossible that they could be found in other languages.

The two types of four-vowel inventories found in Mandarin languages can be compared with the two types of five-vowel inventories in Chapter 3. I lay out the similarities and differences.

In all four types of languages, /ə/ assimilates in place to an adjacent vowel. While this vowel can be either [i] or [u] in Chengde, it can only be [i] in Wuhan, Linfen, and Harbin. The assimilation of /ə/ is the major evidence for place feature specfications in the four languages. The assimilation of the central vowel /ə/ can be compared with two other central vowels, /ɨ/ and /a/. I summarize the patterns in the following table.

(49) Assimilation patterns of the three central vowels in Mandarin languages: "yes" for assimilation; "no" for no assimilation

	Wuhan	Linfen	Chengde	Harbin
/ɨ/	yes	no	vowel not present	no
/ə/	yes	yes	yes	yes
/a/	no	no	no	no

The above table suggests that /ə/ assimilates in all Mandarin languages under study; /ɨ/ assimilates, but only in one language, Wuhan, not in the other languages where it is present. /a/ never assimilates in Mandarin languages. This pattern can be interpreted in structural terms. As I proposed, /ə/ is unspecified for any feature (see, for instance, the representation in (48)). Thus /ə/ is more ready (by being unspecified for feature) to take on features from other segments, compared with /ɨ/ and /a/, which are specified with a height feature. The inertness of the vowel /a/ is discussed by Wu 1994 in Beijing Mandarin. She proposed that /a/ lacks a V-place node. Thus spreading of place feature nodes from other segments is impossible with /a/ owing to the lack of a docking site. A different approach to the pattern in (49) is to follow the idea of vowel dispersion. The low central /a/ is less likely to assimilate than the mid central /ə/, or the high central /ɨ/, because /a/ is at a periphery of the triangle already; the other vowels end up at the periphery of the triangle through assimilation.

The four types of languages share some common constraints, as listed below. Constraint 1 is on the domain of spreading, i.e., the target of spreading must c-command the trigger (see (40) of Chapter 3). Constraint 2 is on the locality of spreading, i.e., the trigger and target must be adjacent to each other at the segmental level (see (17) of Chapter 3). Constraint 3 is a structural constraint on the assimilation of /ə/, i.e., /ə/ in Mandarin only assimilates to a vowel, not to a consonant (see (37) of Chapter 3). Constraint 4 is on the application of the default rule High, i.e., the default rule inserting High only applies to a nuclear vowel when it is singly linked with a place feature (see (57) of Chapter 3). Constraint 5 is an OCP constraint against complex segment *[p^w], i.e., two Labial features within a segment are not allowed in Mandarin by the OCP (see (11) of Chapter 3). Constraint 6 is a structural complexity constraint, i.e., a consonant cannot have a secondary articulation if its place feature has a dependent (see (13) and (70) of Chapter 3). This constraint rules out complex segments such as *[ts^j] and *[$tʂ^j$]. Constraint 7 is against two underlying identical vowel sequences, i.e., *$_\sigma$/V_1-V_1/$_\sigma$ (see (54) of Chapter 3). Constraint 8 is on vowel-vowel sequence, i.e., two consecutive surface high vowels are not allowed in Mandarin (see (51) of Chapter 3). These shared constraints are summarized in Appendix 1.

The languages examined in this chapter lend further support to the contrastive specification approach pursued in this study. In Chengde, there are three phonological vowels at a particular height (/E/, /ə/, and /O/). The theory predicts that only two of them need to be specified for place feature. This is born out by the phonology in the language in that the two vowels specified for a place feature (/E/ and /O/) are both triggers of place assimilation. In Harbin, there are two vowels at a particular height (/E/ and /ə/). The theory predicts that only one of them needs to be specified for place feature. This is again born out by the phonology of the language in that only the vowel specified for a place feature (/E/) is a trigger of place assimilation in the language.

This chapter completes my survey of Mandarin languages with four and five vowel inventories. These are of limited configurations, as discussed in these two chapters. To my knowledge, no Mandarin language has fewer than four vowels phonologically. For instance, Qingdao has six vowels and Anqing seven. The maximum I have found is eight (Yangzhou). These languages elaborate their inventories in expected ways. For instance, they add vowels with specified place. They are less interesting, perhaps, phonologically because more features must be specified in order to capture the contrasts with the system. Thus, I leave these for further study.

Chapter 5 Theoretical issues

In this chapter I address some theoretical issues arising from the discussion in Chapters 3 and 4. In section 5.1 I discuss the issue of the procedure of feature specifications in vowel inventories. In section 5.2 I discuss the issue of markedness revealed by the Mandarin vocalic inventories examined in Chapters 3 and 4. In section 5.3 I conclude the chapter.

5.1 Procedure of feature specifications in vowel inventories

In Chapter 2 I discussed the two major factors that determine feature specifications, namely, phonological processes in the language and contrasts in the system. I also showed that specification of features involves orderings. In particular, for a vowel inventory, since there are two aspects of vowel features, place and height, the ordering of these two properties makes a crucial difference in the process of specification (see section 2.1.1 of Chapter 2). In this section I show with the Mandarin languages presented in Chapters 3 and 4 how different orderings could yield different inventories. In particular, I compare the results of the two different orderings, i.e., place-features-first vs. height-features-first, for each type of inventory. Before I turn to the Mandarin languages, I give a brief review of the literature.

5.1.1 Literature review

Walker 1993 proposes that there is a fixed feature hierarchy, or ordering, in the process of specification of features. In particular, she argues that height features are specified prior to place features. Within the height features, Walker further argues that Low is specified prior to High (if High is necessary at all). Within place features, Labial is ordered prior to Coronal (if Coronal is necessary at all) since Coronal is assumed to be universally less marked than Labial. I take the following five-vowel inventory to illustrate her idea.

(1) Hypothetical vowel inventory: Walker's (1993) procedure of feature specifications

Step 1:

i u

e o separate Low from non-Low

Low a

Step 2:

High i u among non-Low, separate High from non-High

e o

Low a

Steps 3&4:

Labial

High i | u among High, separate Labial from non-Labial

e | o among non-Low non-High, separate Labial from non-Labial

Low a

In each step the positive value of the feature is specified. In the first step, the feature Low is specified on /a/, distinguishing /a/ from the rest of the system. In step 2, among non-low vowels, the feature High is specified on /i/ and /u/, distinguishing these two vowels from /i/ and /o/. /i/ and /o/ are unspecified for height feature. In steps 3 and 4, the feature Labial is specified on /u/ to distinguish /u/ from /i/ (both High), and the feature Labial is specified on /o/ to distinguish /o/ from /e/ (both non-Low and non-High). In my terms, this inventory is actually better thought of phonologically as in (2).

(2) Phonological inventory [i, u, e, o, a] in (1)

ɨ	u
ə	o
a	

Zhang 1996 takes up the issue of ordering of feature specification, arguing that specification of place features cannot be fixed universally. I take Written Manchu to illustrate his idea.

(3) Vowel inventory in Written Manchu: (Zhang 1996)

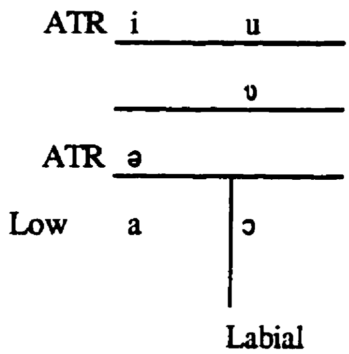
Step 1:

	i	u	
	___	ʊ ___	separate Low from non-Low
	ə		
Low	a	ɔ	

Steps 2 and 3:

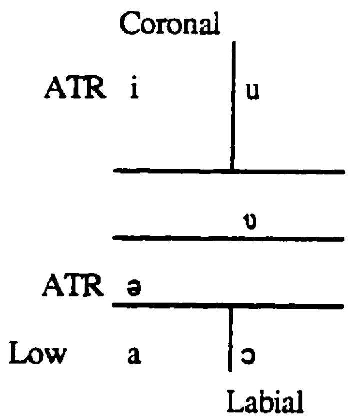
ATR	i ___	u ___	among non-Low, distinguish by ATR
	___	ʊ ___	
ATR	ə ___	___	among Low, distinguish by ATR
Low	a	ɔ	

Step 4 :



among Low non-ATR, separate Labial from non-Labial

Step 5:



among non-Low ATR, separate Coronal from non-Coronal

In step 1, the feature Low is specified on /ə/, /a/, and /ɔ/, to distinguish these three vowels from the rest of the system. In steps 2 and 3, among Low vowels, the feature ATR is specified on /ə/ to distinguish /ə/ from /a/ and /ɔ/; among non-Low vowels, the feature ATR is specified on /i/ and /u/ to distinguish them from /ʊ/. In step 4, between the two Low non-ATR vowels, the feature Labial is specified on /ɔ/ to distinguish it from /a/. Labial is specified since it triggers rounding harmony in the language. In step 5, among the two non-Low ATR vowels, the feature Coronal is specified on the vowel /i/ to distinguish it from /u/. Coronal is specified since it triggers palatalization in the language. Thus the place features Coronal and Labial are ordered differently at different heights. Steps 4 and 5 can be ordered in either way without creating different results.

Having presented some of the literature regarding the ordering of feature specifications, I now discuss the orderings with the Mandarin vowel inventories presented in Chapters 3 and 4. For each type of Mandarin language, I will compare the results from different orderings and show the ordering of feature specification I propose for Mandarin languages. I restrict myself to place before height and height before place and do not examine specifications that would result from the intermingling of these features (e.g., I do not look at the ordering like Coronal-Low-Labial-High or Coronal-Low-High-Labial).

5.1.2 Procedure of feature specifications in Mandarin languages

I start with the Chengde-type inventory, discussed in Chapter 4. Recall that there are 4 vowels in this language. Suppose we separate place features first. I show the relevant steps involved in the process.[21]

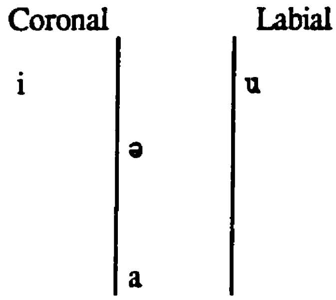
(4) Chengde: steps in place-feature-first specification

Step 1:

```
Coronal
i   |     u
    | ə             separate Coronal from non-Coronal
    | a
```

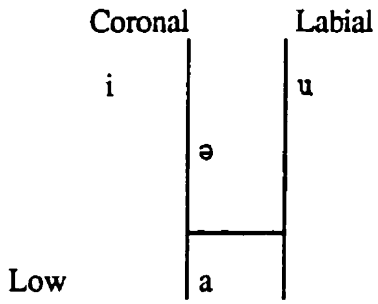
[21]Notice the symbols used are surface forms.

Step 2:



among non-Coronal, separate Labial from non-Labial

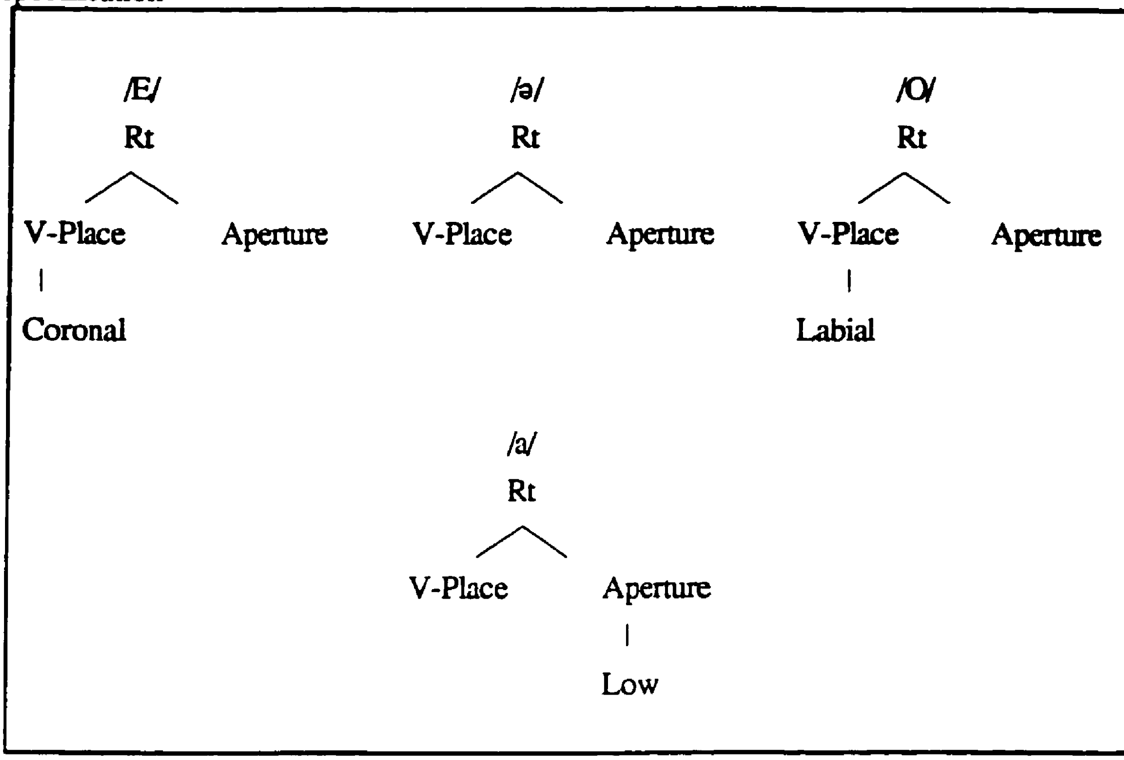
Step 3:



among non-Coronal non-Labial, separate Low from non-Low

Based on distribution and phonology (see Chapter 4), the Chengde underlying system includes one front vowel, one back vowel, and two central vowels. In step 1, the front vowel is distinguished from the non-front vowels and is assigned a place feature, Coronal. In step 2, among the non-front vowels, the back vowel is distinguished from the non-back vowels and is assigned a place feature, Labial. In step 3, the two non-front non-back vowels are distinguished from each other, and from the rest of the system, in that the low central vowel is specified with a height feature, Low, and the mid central vowel left unspecified for height feature. Since the mid central vowel is unspecified for height, phonologically it is at the same level of height as the front and the back vowels. In other words, all three vowels are unspecified for height and so at the same height level. Following are the results of feature specifications.

(5) Feature specifications of vowel inventory in (10): place specification first then height specification



Notice above there are only two phonological heights, Low (1 vowel) and non-Low (3 vowels) (also argued for by Wu 1994 for Beijing Mandarin). I have shown in Chapter 4 how the three non-Low vowels surface in terms of height.

Next I examine the other alternative for the ordering of feature specifications in Chengde, i.e., the height-feature-first. I show below the relevant steps in the process.

(6) Chengde: steps in height-feature-first specification

Step 1: i u

ə ——— separate Low from non-Low

Low a

Step 2: High i__________u among non-Low, separate High from non-High

____ə____

Low a

Step 3: High i__________u among High, which one do we choose?

____ə____

Low a

In step 1 we distinguish the low vowel from the non-low vowels by assigning the low vowel /a/ a height feature Low. In step 2, among non-low vowels, we further distinguish high vowels from non-high vowels by assigning the two high vowels a height feature High. The ordering of steps 1 and 2 is not important. That is, we can either separate the feature Low first, or we can separate the feature High first. As I discussed in Chapter 4, no phonology involving height features has been found in Chengde (or in the other Mandarin languages under study). The specifications of height features above are determined by contrasts.

We see from step 2 that there is only one Low vowel and one non-Low non-High vowel. However, there are two High vowels. They need to be further distinguished from each other. A place feature is required. Either the feature Coronal is specified on /i/, or the feature Labial is specified on /u/, but not both. This is fine with a language in which only one vowel, not both, is found to be active. However, a problem arises with a language in which both vowels are found to be active. This is the situation with the Chengde-type languages, as discussed in Chapter 4.

Recall that in Chengde, both the front vowel /E/ and the back vowel /O/ are active in the phonology in that they both affect a neighboring schwa. More specifically, when /i/

neighbors schwa, it causes schwa to be fronted to [e]. Similarly, when /u/ neighbors schwa, it causes schwa to be rounded to [o]. Thus in this language the place features of both vowels are active and should both be present underlyingly.

This assimilation pattern can be accommodated under the place-feature-first ordering, as shown in (3). That is, the place features of the front and back vowels are active and so must be present underlyingly, requiring two place features Coronal with /i/ and Labial with /u/. The other two vowels in the system, /ə/ and /a/, are central and are distinguished from each other, and from the rest of the system, by the height feature Low.

I summarize the two different orderings of feature specifications with respect to the Chengde-type inventory. The ordering of height-features-first is empirically inadequate. As we see, if height features are specified prior to place features, three heights are defined, which is based on the phonetic heights in the language given that there is no evidence to suggest otherwise. With three heights, and further two vowels at the High level, a place feature, and one ONLY, is needed in order to distinguish the two High vowels. However, in Chengde and similar languages, both of the two vowels assigned High under height-place specification are active in the phonology, triggering place assimilation of a neighboring schwa. Thus both should be specified for a place feature. As we see, this problem does not exist with the other ordering, i.e., place-first. For this reason, I propose that for the Chengde type of Mandarin languages, place features should be specified prior to height features.

Next I discuss a second type of Mandarin language, Harbin, with respect to the ordering of vowel feature specifications. Recall from Chapter 4 that there are four underlying vowels in the Harbin inventory. First I discuss the ordering of place-feature-first (as required in Chengde). I show the steps involved in the process.

(7) Harbin: steps in place-feature-first specification

Step 1:

Coronal

E | ɨ

| ə — separate Coronal from non-Coronal

| a

Step 2:

Coronal

E | ɨ

| ə — among non-Coronal, separate Low from non-Low

Low | a

Step 3:

Coronal

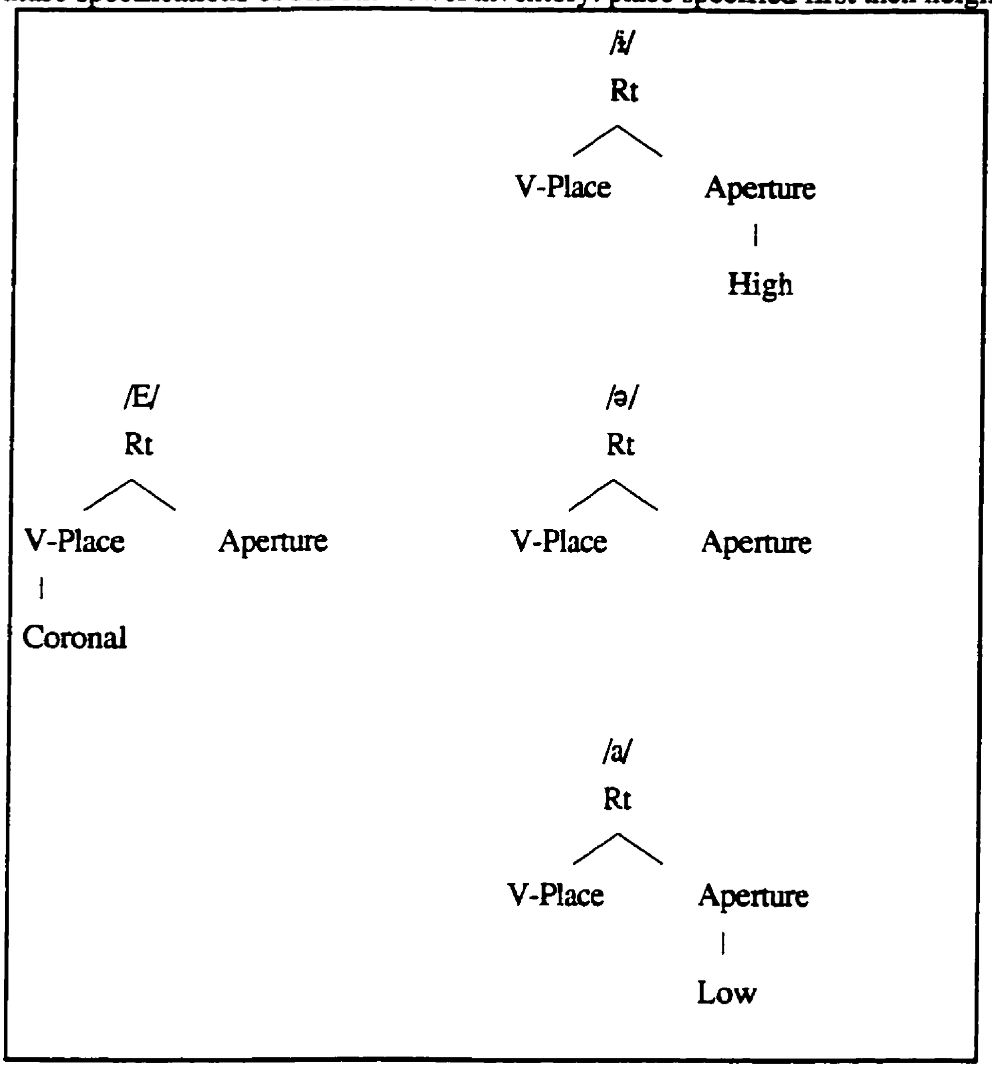
High | ɨ

E | ə — among non-Coronal non-Low, separate High from non-High

Low | a

In Chapter 4 I have shown, based on distribution and phonology, that there are three central vowels and one front vowel in Harbin. In step 1, the front vowel is distinguished from the other 3 vowels by being given the place feature Coronal. In steps 2 and 3, the three central vowel are further distinguished in that /a/ is assigned the height feature Low, /ɨ/ is assigned the height feature High, and /ə/ is left unspecified. Again the ordering between steps 2 and 3 is flexible. Following are the results of feature specification.

(8) Feature specifications of Harbin vowel inventory: place specified first then height



Notice that the front vowel /E/ is specified with only a place feature. I discussed in Chapter 4 that this vowel surfaces as high through a default rule.

Next I show how vowel features are specified in Harbin with the ordering height-feature-first.

(9) Harbin: steps in height-feature-first specification

Step 1:

i ɨ

ə — separate Low from non-Low

Low a

Step 2:

High i ɨ — among non-Low, separate High from non-High

ə

Low a

Step 3:

Coronal

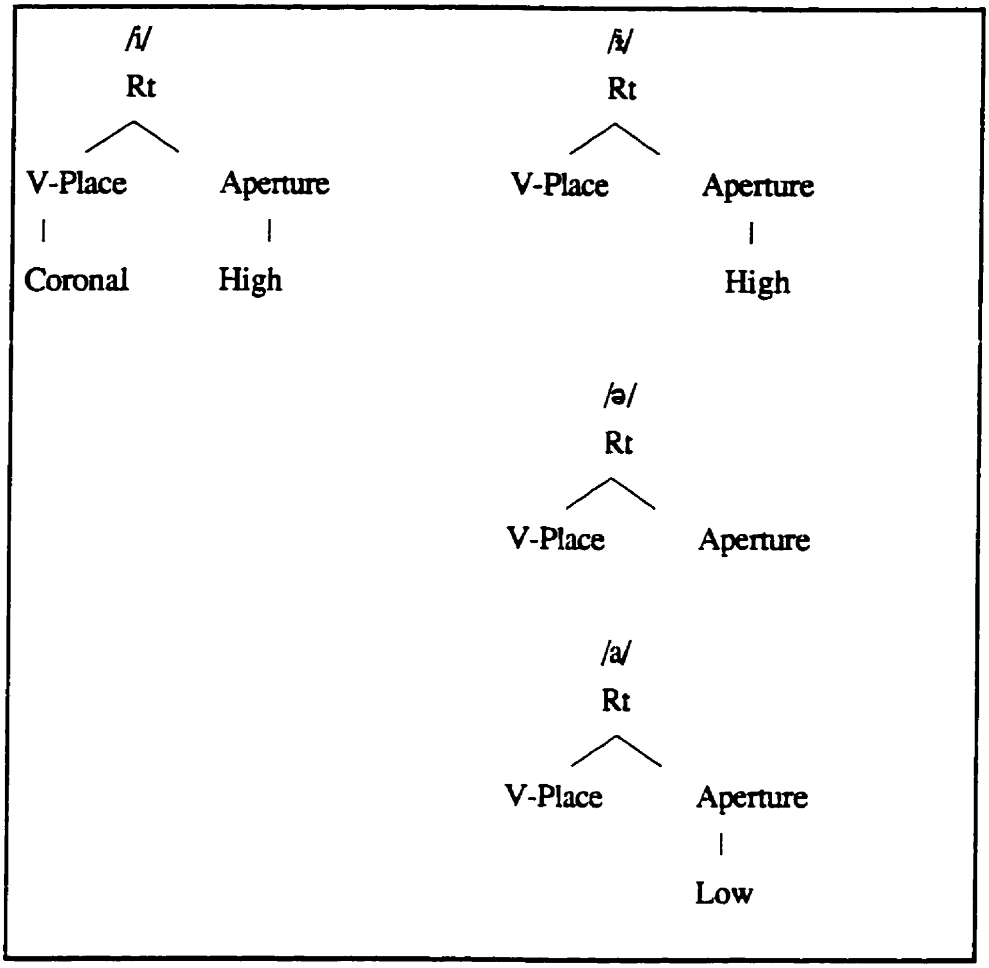
High i | ɨ — among High, separate Coronal from non-Coronal

ə

Low a

In step 1, the low vowel /a/ is distinguished from the non-low vowels and is assigned the height feature Low. In step 2, among non-Low vowels, the high vowels /i/ and /ɨ/ are distinguished from the non-low and non-high vowel /ə/; the two high vowels are assigned the height feature High. The ordering between steps 1 and 2 is flexible. In step 3, the two High vowels need to be further distinguished from each other. I discussed in Chapter 4 that the front vowel /i/ should be specified with the place feature Coronal, based on its distribution and phonology in the language. Following are the results of feature specifications with the ordering height-feature-first.

(10) Feature specifications of Harbin vowel inventory: height specifications first then place specifications



Comparing (10) with (8), the two results from the two different orderings of feature specifications, we see that the difference lies in the front vowel, /i/ in (10) and /E/ in (8). In (10), we start from height features. While there is only one Low vowel and one non-Low non-High vowel, there are two High vowels, /i/ and /ɨ/. /i/ and /ɨ/ are further distinguished in that /i/ is specified with Coronal. Thus the front vowel /i/ is specified with a height AND a place feature.

However, in (8), we start from place features. The front vowel, /E/, is specified as Coronal and is thus distinguished from the other vowels in the system. /i/ surfaces as the high vowels [i], [ɿ], and [ʅ] through a default rule of inserting High. This shows that the same vowel inventory could have different feature specifications, particularly the front vowel in the case of Harbin, depending on the ordering of feature specifications. Both give the same results empirically.

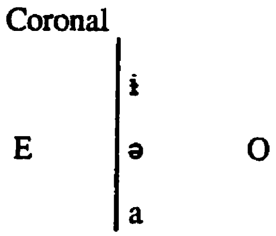
There are pros and cons to both alternatives discussed. With place-feature-first, the front vowel is only specified with one feature, Coronal. However, an extra default rule which inserts High is required. On the other hand, with height-feature-first specification, the front vowel is specified with two features, Coronal and High. One more feature is specified on /i/. However, no default rule inserting High is required.

I assume the place-feature-first ordering. The reasoning is as follows. I assume that a default rule, in this case High on the front vowel, is part of the language-universal principles of phonology. This can be understood in that a default rule is built into a child's language capacity. On the other hand, an extra feature specified on a vowel (the feature High in this case) can be regarded in that some extra learning/memory is required in order to acquire that feature. I assume that it is more important to keep specified features as few as possible, than to avoid a default rule. For this reason, I prefer (8), resulting from the ordering place-feature-first.

Next I discuss the third type of Mandarin language, Wuhan/Linfen, with respect to the feature-specification ordering issue. Recall that both Wuhan and Linfen have the same inventory, though they differ in the way the vowel /ɨ/ surfaces. I treat the two inventories as one for the present purposes. First I discuss the place-feature-first alternative. I show the steps involved in the process.

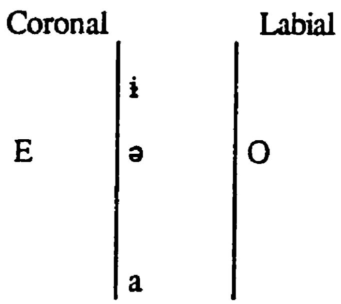
(11) Wuhan/Linfen: steps in place-feature-first specification

Step 1:



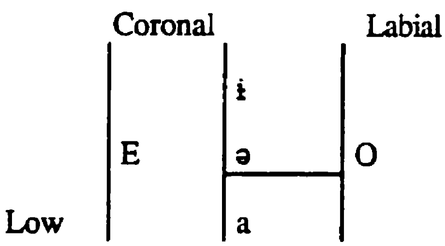
separate Coronal from non-Coronal

Step 2:



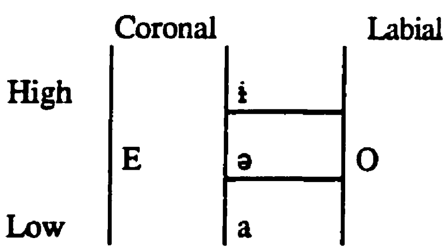
among non-Coronal, separate Labial from non-Labial

Step 3:



among non-Coronal and non-Labial, separate Low from non-Low

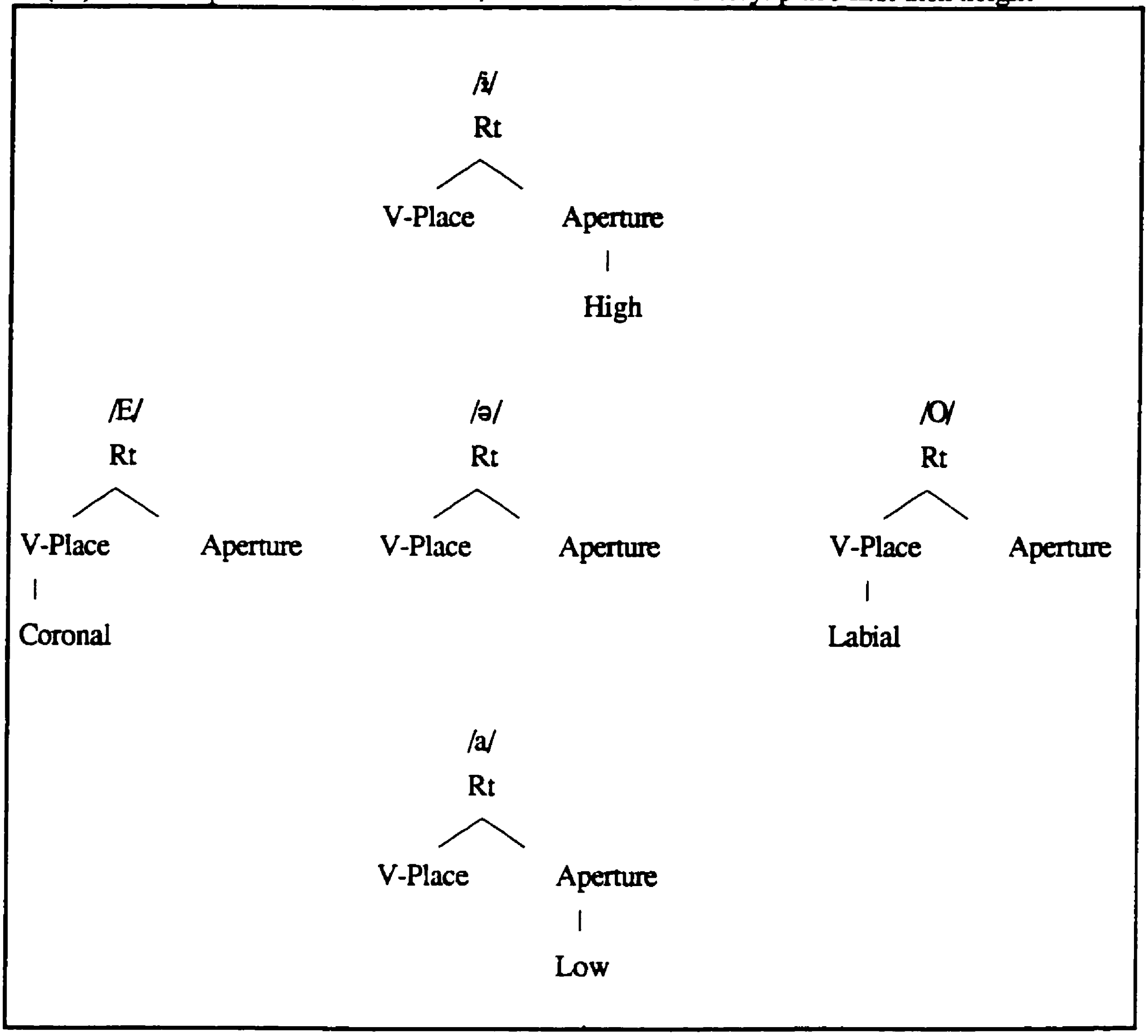
Step 4:



among non-Coronal non-Labial and non-Low, separate High from non-High

I discussed in Chapter 3 that there are three central vowels, one front vowel, and one back vowel in the system, based on both distribution and phonology. In step 1, the front vowel /E/ is distinguished from the other 4 vowels by being assigned Coronal. In step 2, among the non-front vowels, the back vowel /O/ is distinguished from the non-back vowels and is assigned the feature Labial. The ordering between steps 1 and 2 is indeterminate. In steps 3 and 4, the three non-front and non-back vowels are further distinguished in that the low vowel /a/ is specified with the height feature Low, the high vowel /ɨ/ with the height feature High, and the mid vowel /ə/ left unspecified for any feature. Following are the results of feature specifications with place-feature-first.

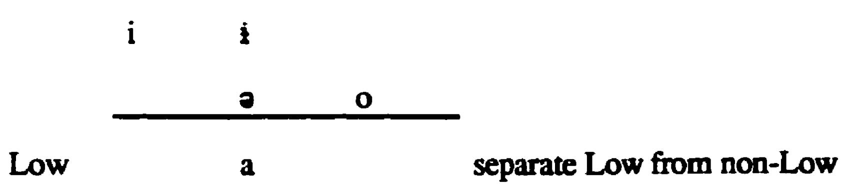
(12) Feature specifications of Wuhan/Linfen vowel inventory: place first then height



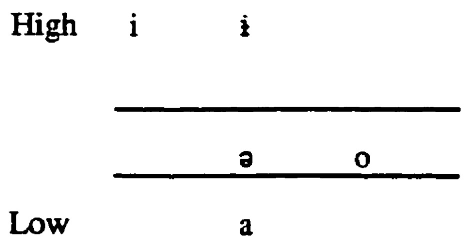
Next I compare the alternative ordering, height-feature-first, for Wuhan/Linfen. Following are the steps involved in the process.

(13) Wuhan/Linfen: steps in height-feature-first specification

Step 1:

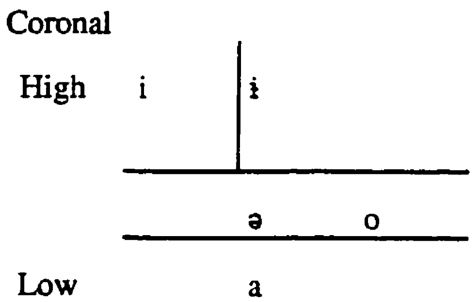


Step 2:



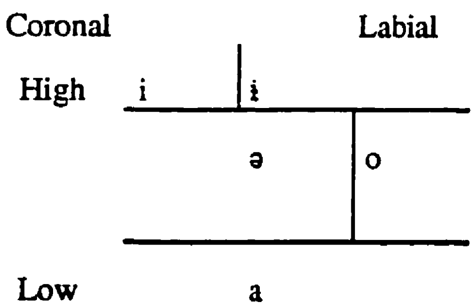
among non-Low, separate High from non-High

Step 3:



among High, separate Coronal from non-Coronal

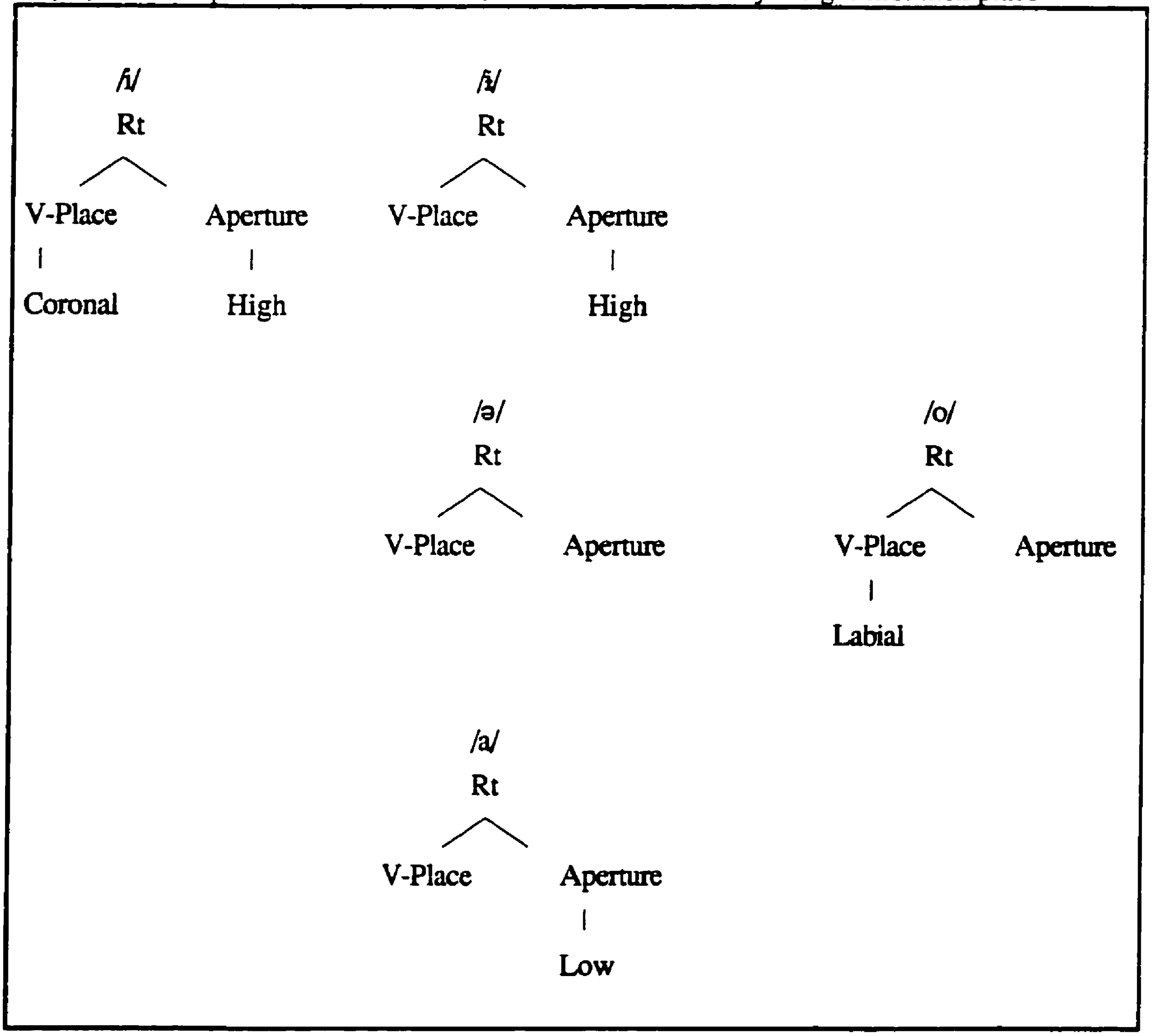
Step 4:



among non-Low non-High, separate Labial from non-Labial

In step 1, the low vowel /a/ is distinguished from the non-low vowels and is assigned the height feature Low. In step 2, among non-Low vowels, the high vowels /i/ and /ɨ/ are distinguished from the mid vowels /ə/ and /o/; the two high vowels are assigned the height feature High. The ordering between steps 1 and 2 is flexible. There are two High vowels and two non-Low non-High vowels. In step 3, the two High vowels are distinguished from each other in that the front vowel /i/ is specified with the place feature Coronal, since this feature is active in the language (recall from Chapter 3). In step 4, the two non-Low and non-High vowels are further distinguished from each other in that the back vowel /o/ is specified with the place feature Labial, since the other vowel at this height level is central. The ordering between steps 3 and 4 is flexible. Following are the results of feature specification with the height-feature-first ordering.

(14) Feature specifications of Wuhan/Linfen vowel inventory: height first then place



Comparing (14) with (12), we notice that the major difference between the two different orderings is the front vowel, /i/ in (14) and /E/ in (12). This resembles the situation found in Harbin, discussed in section 4.2 of Chapter 4. That is, with the place-feature-first ordering, the front vowel is specified with only one feature, Coronal, but needs a default rule inserting High. On the other hand, with the height-feature-first ordering, the front vowel is specified with two features, Coronal and High; no default rule inserting High is required. I have discussed for Harbin that it is more important, from a language acquisition point of view, to keep the specified features as few as possible, than to avoid a default rule. For this reason, I prefer the inventory in (12), which results from the ordering place-feature-first.

To summarize, I have compared the two different feature-specification orderings with respect to the Mandarin vowel inventories presented in Chapters 3 and 4. All three types of inventories suggest that the ordering of place-feature-first is to be preferred over height-feature-first, but for different reasons. For Harbin and Wuhan/Linfen, the reason is that the place-feature-first ordering results in fewer features specified. For Chengde, only the place-feature-first ordering, not the other one, is empirically adequate for the language.

5.2 Markedness in Mandarin vowel inventories

In Chapters 3 and 4 I have introduced four different types of Mandarin vowel inventories. These inventories differ in shape, depending on the features each vowel is specified with. In this section I discuss the implications of these vowel inventories, with respect to vowel markedness.

It has been commonly argued that there is a markedness hierarchy among consonants. Particularly, coronal consonants, among consonants of other places of articulation, are believed to be less marked (Kiparsky 1985, Avery and Rice 1988, 1989, papers in Paradis and Prunet 1991, Rose 1993, among others). "Less marked" is understood in the sense that coronal consonants are more common in terms of frequency, are the targets of phonological processes such as assimilation and vowel harmony, and are the epenthetic/default segments of the language, among other types of criteria. Assuming that consonants and vowels share the same bundle of place features, it is natural to ask if such a markedness hierarchy, or any markedness hierarchy, is found among vowels.

In works such as Rose 1993, Walker 1993, and Hume 1996, a similar markedness pattern is found for vowels compared with the pattern for consonants. More specifically, just as coronal consonants are believed to be less marked in certain ways, coronal/front vowels are also found to be less marked compared with vowels of other place features. Here I give one example, returning to Afar, discussed in Chapter 2. In Afar (Rose 1993), the following vowel inventory is found.

(15) Afar surface vowel inventory

i		u	i:		u:
e		o	e:		o:
	a			a:	

In the above inventory, each of the five vowels has a short and a long version.

In Afar, front vowels and back vowels pattern asymmetrically in terms of place assimilation. More specifically, front vowels assimilate to back vowels of equal height. Based on this, Rose argued that the place features of the front vowels must be absent underlyingly, while the place features of the back vowels are present, as shown below.

(16) Afar: front vowels unspecified for place features; back vowels specified for place

i, e	u, o
V-Pl	V-Pl
	|
	Labial

Thus the assimilation of front vowels to back vowels can be structurally viewed as front vowels, with a bare place node, taking on the Labial place feature node from the back vowels. The conclusion accordingly is that coronal vowels, [i] and [e] in the case of Afar, are less marked than labial vowels, [u] and [o] in Afar. The reader is referred to the above-mentioned works for similar conclusions drawn from other languages, based on various types of evidence.

While the above view basically agrees with the markedness pattern established for consonants, a different view is held by Zhang 1996, based on observations of Manchu-Tungus languages. In Written Manchu, the following vowel inventory is found.

(17) Surface vowel inventory in Written Manchu (Zhang 1996)

i	u	
	ʊ	Non-low
ə		
a	ɔ	Low

There are two heights in the above inventory, low and non-low (within each height a further distinction is made by ATR/RTR). It is found that in Written Manchu different phonological processes involve different vowels. The vowel [i] causes consonant palatalization. However, the other two non-low vowels, which are back, do not participate in any phonological processes, including labial vowel-harmony, which involves low vowels. Based on these patterns, Zhang concludes that among non-low vowels, the front vowel should be specified with a Coronal place feature, and the back vowels left unspecified for place. On the other hand, among low vowels, it is found that the back vowel [ɔ] is active in the phonology, triggering labial harmony. The other two low vowels are central vowels. Thus Zhang concludes that for low vowels, the back vowel is specified for a place feature Labial, and the two central vowels are unspecified for place. Thus, the place feature Coronal is marked for the non-low vowel whereas the place feature Labial is marked for the low vowel, as shown below.

(18) Written Manchu: Coronal marked for non-low vowel; Labial marked for low vowel

i	ɔ	u, ʊ, ə, a
V-Pl	V-Pl	V-Pl
|	|	
Coronal	Labial	

The above pattern suggests that in Written Manchu, vowels at different heights are specified with different place features. Thus, for Written Manchu, and for languages of the Manchu-Tungus group in general, there is no fixed markedness hierarchy of place features, i.e., the hierarchy found for languages such as Afar.

Having introduced some background on the issue of vowel-place-feature markedness, I turn to the Mandarin languages examined in Chapters 3 and 4. Recall that there are four types of Mandarin languages discussed in the two chapters. The two five-vowel inventories are identical in shape, though they differ in the way some of the vowels (particularly the vowel /ɨ/) surface, so I treat them as one inventory here. I repeat below the three Mandarin vowel inventories.

(19) Three Mandarin vowel inventories

a) Wuhan and Linfen vowel inventory:

ɨ

E ə O

a

b) Harbin vowel inventory:

ɨ

E ə

a

c) Chengde vowel inventory:

E ə O

a

I focus on place specifications. As discussed in Chapter 3, in the Wuhan/Linfen inventory, Coronal is specified on /E/ and Labial on /O/. In other words, both Coronal and Labial place features are specified in this system. In the Harbin inventory, Coronal is specified on /E/. There is no back vowel in this system and so Labial is not specified. In the Chengde inventory, place feature Coronal is specified on /E/ and Labial is specified on /O/. Thus like Wuhan and Linfen, both Coronal and Labial place features are present in this system. I summarize the above patterns.

(20) Vowel place feature specification patterns in Mandarin languages

	Coronal specified	Labial specified
Wuhan/Linfen-type	yes	yes
Chengde-type	yes	yes
Harbin-type	yes	no

As we see, whereas Coronal is always specified in the Mandarin vowel inventories, Labial varies in terms of whether it is present phonologically. It is specified in the Wuhan/Linfen and Chengde-type inventories, but not in the Harbin-type inventory.

What the pattern in table (20) suggests is that for Harbin the place feature Coronal is more marked than the place feature Labial, since Coronal is marked, or specified in the inventory, whereas Labial is not.

5.3 Conclusions

In this chapter I have discussed alternative approaches to the ordering of feature specification of the languages in Chapters 3 and 4, and have shown that place features need to be specified prior to height features in Mandarin. I have also discussed the markedness issue arising from the Mandarin vowel inventories and have shown that the place feature Coronal is more marked than the place feature Labial at least in one Mandarin language, Harbin.

Chapter 6 Conclusions

In this chapter I summarize the major contributions of the thesis.

It has been long assumed in the Chinese literature that surface vowel [ɤ] is the lengthened form of the vowel [ə], motivated by the Chinese syllable structure requirement of two timing slots in the rime on the surface. I have provided lexical evidence for such an assumption. That is, it is found in different Mandarin languages among different lexical items that [ə] surfaces differently in a full-tone syllable from a neutral-tone syllable syllable. In a full-tone syllable, i.e., Tones 1, 2, 3, and 4, [ə] surfaces as [ɤ] because a full tone can be regarded as long and thus requires a long surface form, which is [ɤ]. On the contrary, in a neutral-tone syllable, [ə] surfaces as [ə] itself since a neutral tone is short in time and so a short surface form [ə] is fine in such a syllable.

I have spelled out details regarding the structural constraints on place feature spreading/assimilation in Mandarin. One constraint is that the target should c-command the trigger. The second constraint is the trigger and the target should be adjacent to each other. The third constraint concerns specifically the vowel /ə/. That is, /ə/ only assimilates to a vowel, not to a consonant.

The Mandarin languages under study lend support to the feature underspecification approach as laid out in section 2.1 of Chapter 2. Particularly, while in Harbin-type languages, only the front vowel /E/ acts as a trigger of place assimilation, in Chengde-type languages, both the front vowel /E/ and the back vowel /O/ act as a trigger of place assimilation. These patterns are captured by the contrastive specification approach. In Harbin, only the front vowel /E/ is specified with a place feature (the back vowel [u] is unspecified with a place feature) and so only /E/ acts as a trigger of assimilation. In Chengde, both /E/ and /O/ are specified with a place feature and so both are triggers of assimilation. These patterns would be difficult to explain under a different approach, say, full specification, in which case the assimilation rules would have to refer to specific place features (Coronal only in Harbin and Coronal and Labial in Chengde) and so is stipulative. My analysis predicts that feature activity relates to inventory shape; in a full specification approach there is no necessary connection between inventory type and feature activity.

In the feature specification literature, different orderings of specification have been suggested depending on the particular languages being studied. The Mandarin languages in this study suggest that place features need to be specified prior to height features. Further there is no fixed hierarchy among place features. Place feature specifications are determined by the requirements of phonological behavior and contrasts in the language.

The Mandarin languages have shown three types of phonological vowel inventories. We have seen an inventory with three phonological heights, with only one high and low vowel, but three mid vowels (front-central-back; the Wuhan/Linfen type). We have also seen an inventory with two heights, with only one low vowel, and three non-low vowels (front-central-back; the Chengde type). We have seen a third inventory with three heights, with only one low and high vowel, but two mid vowels (front-central; the Harbin type). These inventories are the results of the feature-specification procedures I have argued for.

Lastly it has also been argued that in Harbin the place feature Coronal is more marked than the place feature Labial since Coronal is always specified in the system whereas Labial is not. This lends support to Zhang's 1996 conclusion that Labial is an unmarked vowel place feature, at least for languages within China.

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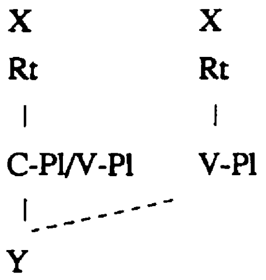
Appendix 1: Summary of constraints in Mandarin languages

A. Common constraints to Mandarin languages

(1) Constraint on domain of spreading: The target c-commands the trigger.

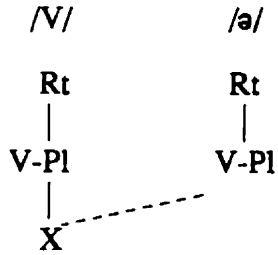
(see (40) of Chapter 3)

(2) Constraint on locality in assimilation:



(see (17) of Chapter 3)

(3) Structural constraint on assimilation of /ə/: /ə/ assimilates to an adjacent vowel (mirror image):



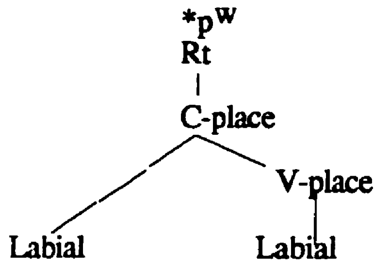
(see (37) of Chapter 3)

(4) Constraint on the application of the default rule High:

The default rule inserting High applies to a nuclear vowel only if it is singly linked with a place feature.

(see (57) of Chapter 3)

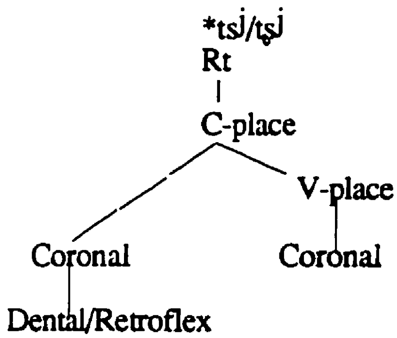
(5) OCP constraint against complex segment *[p^w] (at both underlying and surface levels):



Domain: segment

(see (11) of Chapter 3)

(6) Structural complexity constraint (see (13) and (70) of Chapter 3):



(7) Constraint against two underlying identical vowel sequences: $*_{\sigma}/V_1\text{-}V_1/_{\sigma}$

(see (54) of Chapter 3)

(8) Constraint against two surface high vowels sequence: $*_{\sigma}[\text{high-high}]_{\sigma}$

(see (51) of Chapter 3)

Particular constraints in Mandarin languages:

(1) Rule ordering in Chengde: Coronal spreading applies before Labial spreading.

(see section 4.1.3.1 of Chapter 4)

(2) OCP constraint against two adjacent Coronal segments in rime in Linfen, Chengde, and Harbin (not in Wuhan; evidence from r-suffixation)

```
*   X             Y
    Rt            Rt
    |             |
    C-Pl/V-Pl     C-Pl
    |             |
    Coronal       Coronal
```

(see section 3.2.3.3 of Chapter 3)

Appendix 2: Tables of Wuhan, Linfen, Harbin, and Chengde

(In each table the heading column and the heading row are underlying forms. The rest of the table are surface forms.)

Wuhan

Wuhan Table 1 Syllables headed by plain consonants

	a	ə	O	E	ɨ	aE	əE	aɨ	Oɨ	an	ən	aŋ	Oŋ	m̩	n̩	ŋ̍
p	pa	pɤ	po	pi	pu	paj	pej	paw		pan	pən	paŋ	poŋ			
p'	p'a	p'ɤ	p'o	p'i	p'u	p'ai	p'ej	p'aw		p'an	p'ən	p'aŋ	p'oŋ			
m	ma	mɤ	mo	mi		maj	mej	maw	mow	man	mən	maŋ	moŋ			
f	fa				fu		fej		fow	fan	fən	faŋ	foŋ			
t	ta	tɤ	to	ti		taj	tej	taw	tow	tan	tən	taŋ	toŋ			
t'	t'a	t'ɤ	t'o	t'i		t'aj	t'ej	t'aw	t'ow	t'an	t'ən	t'aŋ	t'oŋ			
n	na	nɤ	no	ni		naj	nej	naw	now	nan	nən	naŋ	noŋ			
ʦ	ʦa	ʦɤ	ʦo	ʦɿ		ʦaj	ʦej	ʦaw	ʦow	ʦan	ʦən	ʦaŋ	ʦoŋ			
ts'	ts'a	ts'ɤ	ts'o	ts'ɿ		ts'aj	ts'ej	ts'aw	ts'ow	ts'an	ts'ən	ts'aŋ	ts'oŋ			
s	sa	sɤ	so	sɿ		saj	sej	saw	sow	san	sən	saŋ	soŋ			
r																
k	ka	kɤ	ko	ʨi	ku	kaj		kaw	kow	kan	kən	kaŋ	koŋ			
k'	k'a	k'ɤ	k'o	ʨ'i	k'u	k'aj		k'aw	k'ow	k'an	k'ən	k'aŋ	k'oŋ			
ŋ	ŋa	ŋɤ	ŋo			ŋaj		ŋaw	ŋow	ŋan	ŋən	ŋaŋ	ŋoŋ			
x	xa	xɤ	xo	ɕi	xu	xaj		xaw	xow	xan	xən	xaŋ	xoŋ			
0	a	ɤ	o	i	u									m̩	n̩	ŋ̍

Wuhan Table 2 Syllables headed by consonants with palatalization

	a	ə	O	E	ɨ	aE	əE	aɨ	Oɨ	an	ən	aŋ	Oŋ	m̩	n̩	ŋ̍
p^E	pʲa	pʲe						pʲaw			pʲən	pʲaŋ				
$p^{E'}$	pʲ'a	pʲ'e						pʲ'aw			pʲ'ən	pʲ'aŋ				
m^E		mʲe						mʲaw	mʲow		mʲən					
f^E																
t^E	tʲa	tʲe						tʲaw	tʲow		tʲən	tʲaŋ	tʲoŋ			
$t^{E'}$	tʲ'a	tʲ'e						tʲ'aw			tʲ'ən	tʲ'aŋ				
n^E	nʲa	nʲe	nʲo		nü			nʲaw	nʲow		nʲən	nʲaŋ				
ts^E																
$ts^{E'}$																
s^E																
r^E																
k^E	ʨa	ʨe	ʨo		ʨü			ʨaw	ʨow		ʨən	ʨaŋ	ʨoŋ			
$k^{E'}$	ʨ'a	ʨ'e	ʨ'o		ʨ'ü			ʨ'aw	ʨ'ow		ʨ'ən	ʨ'aŋ	ʨ'oŋ			
$ŋ^E$	ŋa															
x^E	ɕa	ɕe	ɕo		ɕü			ɕaw	ɕow		ɕən	ɕaŋ	ɕoŋ			
E	ja	je	jo		ü			jaw	jow		jən	jaŋ	joŋ			

Wuhan Table 3 Syllables headed by consonants with labialization

	a	ɵ	O	E	ɨ	aE	əE	aɨ	Oɨ	an	ən	aŋ	Oŋ	m̩	n̩	ŋ̍
pɨ																
pɨ'																
mɨ																
fɨ																
tɨ																
tɨ'																
nɨ				nü												
tsɨ	$ts^{W}a$					$ts^{W}aj$	$ts^{W}ej$			$ts^{W}an$		$ts^{W}aŋ$				
tsɨ'	ts^{W}'a					ts^{W}'aj	ts^{W}'ej			ts^{W}'an		ts^{W}'aŋ				
sɨ	$s^{W}a$	s^{W}ɤ				$s^{W}aj$	$s^{W}ej$			$s^{W}an$		$s^{W}aŋ$				
rɨ	$r^{W}a$					$r^{W}aj$	$r^{W}ej$									
kɨ	$k^{W}a$	k^{W}ɤ		ʨü		$k^{W}aj$	$k^{W}ej$			$k^{W}an$	k^{W}ən	$k^{W}aŋ$				
kɨ'	k^{W}'a			ʨ'ü		k^{W}'aj	k^{W}'ej			k^{W}'an	k^{W}'ən	k^{W}'aŋ				
ŋɨ																
xɨ	$x^{W}a$	x^{W}ɤ		ɕü		$x^{W}aj$	$x^{W}ej$			$x^{W}an$	x^{W}ən	$x^{W}aŋ$				
ɨ	wa			ü		waj	wej			wan	wən	waŋ				

Wuhan Table 4 Syllables headed by consonants with both palatalization and labialization

	a	ə	O	E	ɨ	aE	əE	aɨ	Oɨ	an	ən	aŋ	Oŋ	m̩	n̩	ŋ̍
$p^{Eɨ}$																
$p^{Eɨ'}$																
$m^{Eɨ}$																
$f^{Eɨ}$																
$t^{Eɨ}$																
$t^{Eɨ'}$																
$n^{Eɨ}$																
$ʦ^{Eɨ}$																
$ts^{Eɨ'}$																
$s^{Eɨ}$																
$r^{Eɨ}$																
$k^{Eɨ}$		$ʨ^{w}e$									$ʨ^{w}ən$					
$k^{Eɨ'}$		$ʨ^{w'}e$									$ʨ^{w'}ən$					
$ŋ^{Eɨ}$																
$x^{Eɨ}$		$ɕ^{w}e$									$ɕ^{w}ən$					
Eɨ		ɥe									ɥən					

Linfen

Linfen Table 1 Syllables headed by plain consonants

	a	ə	O	E	ɨ	aE	əE	aɨ	əɨ	an	ən	aŋ	əŋ
p	pa	pɤ	po	pi	pu	paj	pej	paw		pan	pən	paŋ	pəŋ
p'	p'a	p'ɤ	p'o	p'i	p'u	p'aj	p'ej	p'aw		p'an	p'ən	p'aŋ	p'əŋ
m	ma	mɤ	mo	mi	mu	maj	mej	maw		man	mən	maŋ	məŋ
f	fa		fo		fu	faj	fej			fan	fən	faŋ	fəŋ
v	va		vo	vi	vu							vaŋ	vəŋ
t	ta		to	ti	tu	taj	tej	taw	təw	tan	tən	taŋ	təŋ
t'	t'a	t'ɤ	t'o	t'i	t'u	t'aj	t'ej	t'aw	t'əw	t'an	t'ən	t'aŋ	t'əŋ
n	na		no	ni		naj	nej	naw	nəw	nan	nən	naŋ	nəŋ
l	la	lɤ	lo	li		laj			ləw		lən	laŋ	ləŋ
ʦ	ʦa		ʦo	ʦɿ		ʦaj	ʦej	ʦaw	ʦəw	ʦan	ʦən	ʦaŋ	ʦəŋ
ts'	ts'a		ts'o	ts'ɿ		ts'aj	ts'ej	ts'aw	ts'əw	ts'an		ts'aŋ	
s	sa	sɤ	so	sɿ		saj	sej	saw	səw	san	sən	saŋ	səŋ
ʈʂ	ʈʂa	ʈʂɤ	ʈʂo	ʈʂʅ	ʈʂu	ʈʂaj			ʈʂəw		ʈʂən		ʈʂəŋ
tʂ'	tʂ'a	tʂ'ɤ	tʂ'o	tʂ'ʅ	tʂ'u	tʂ'aj			tʂ'əw		tʂ'ən		tʂ'əŋ
ʂ	ʂa	ʂɤ	ʂo	ʂʅ	ʂu	ʂaj			ʂəw		ʂən		ʂəŋ
r	ra	rɤ	ro	rʅ					rəw		rən		rəŋ
k	ka	kɤ	ko	ʨi	ku	kaj		kaw	kəw	kan	kən	kaŋ	kəŋ
k'	k'a	k'ɤ	k'o	ʨ'i	k'u	k'aj		k'aw	k'əw	k'an	k'ən	k'aŋ	k'əŋ
ŋ	ŋa	ŋɤ	ŋo			ŋaj		ŋaw	ŋəw	ŋan	ŋən	ŋaŋ	
x	xa	xɤ	xo	ɕi	xu	xaj		xaw	xəw	xan	xən	xaŋ	xəŋ
0	a		o	i	u								

Linfen Table 2 — Syllables headed by consonants uith palatalization

	a	ə	O	E	ɨ	aE	əE	aɨ	əɨ	an	ən	aŋ	əŋ
p^E	pʲa	pʲe						pʲaw		pʲan	pʲən		pʲəŋ
$p^{E'}$	pʲ'a	pʲ'e						pʲ'aw		pʲ'an	pʲ'ən		pʲ'əŋ
m^E	mʲa	mʲe						mʲaw		mʲan	mʲən		mʲəŋ
f^E													
v^E													
t^E	tʲa	tʲe						tʲaw	tʲəw	tʲan			tʲəŋ
$t^{E'}$	tʲ'a	tʲ'e						tʲ'aw		tʲ'an			tʲ'əŋ
n^E	nʲa	nʲe			nü			nʲaw	nʲəw	nʲan	nʲən	nʲaŋ	nʲəŋ
l^E	lʲa	lʲe			lü			lʲaw	lʲəw	lʲan	lʲən	lʲaŋ	lʲəŋ
ts^E													
$ts^{E'}$													
s^E													
$tʂ^E$													
$tʂ^{E'}$													
$ʂ^E$													
r^E													
k^E	ʨa	ʨe			ʨü	ʨaj		ʨaw	ʨəw	ʨan	ʨən	ʨaŋ	ʨəŋ
$k^{E'}$	ʨ'a	ʨ'e			ʨ'ü			ʨ'aw	ʨ'əw	ʨ'an	ʨ'ən	ʨ'aŋ	ʨ'əŋ
$ŋ^E$													ɕʲəŋ
x^E	ʨ'a	ɕe			ɕü	ɕaj		ɕaw	ɕəw	ɕan	ɕən	ɕaŋ	
E	ja	je			ü			jaw	əw	an	jən	jaŋ	jəŋ

Linfen Table 3 Syllables headed by consonants with labialization

	a	ə	O	E	ɨ	aE	əE	aɨ	əɨ	an	ən	aŋ	əŋ
p^{ɨ}													
p^{ɨ}’													
m^{ɨ}													
f^{ɨ}													
v^{ɨ}													
t^{ɨ}							t^{w}ej			t^{w}an	t^{w}ən		t^{w}əŋ
t^{ɨ}’							t^{w}’ej			t^{w}’an	t^{w}’ən		t^{w}’əŋ
n^{ɨ}				nü									
l^{ɨ}				lü						l^{w}an	l^{w}ən	l^{w}aŋ	
ts^{ɨ}							ts^{w}ej			ts^{w}an	ts^{w}ən		ts^{w}əŋ
ts^{ɨ}’							ts^{w}’ej			ts^{w}’an	ts^{w}’ən		ts^{w}’əŋ
s^{ɨ}							s^{w}ej			s^{w}an	s^{w}ən		s^{w}əŋ
tʂ^{ɨ}	tʂ^{w}a						tʂ^{w}ej			tʂ^{w}an	tʂ^{w}ən	tʂ^{w}aŋ	tʂ^{w}əŋ
tʂ^{ɨ}’	tʂ^{w}’a						tʂ^{w}’ej			tʂ^{w}’an	tʂ^{w}’ən	tʂ^{w}’aŋ	tʂ^{w}’əŋ
ʂ^{ɨ}							ʂ^{w}ej					ʂ^{w}aŋ	
r^{ɨ}													
k^{ɨ}	k^{w}a		k^{w}o	ʨü		k^{w}ai	k^{w}ej			k^{w}an	k^{w}ən	k^{w}aŋ	k^{w}əŋ
k^{ɨ}’	k^{w}’a		k^{w}’o	ʨ’ü		k^{w}’ai	k^{w}’ej			k^{w}’an	k^{w}’ən	k^{w}’aŋ	k^{w}’əŋ
ŋ^{ɨ}	ŋ^{w}a												
x^{ɨ}	x^{w}a		x^{w}o	ɕü		x^{w}ai	x^{w}ej			x^{w}an	x^{w}ən	x^{w}aŋ	x^{w}əŋ
ɨ	wa		wo	ü		wai	wej			wan	wən	waŋ	wəŋ

Linfen Table 4 Syllables headed by consonants with both palatalization and labialization

	a	ə	O	E	ɨ	aE	əE	aɨ	əɨ	an	ən	aŋ	əŋ
pEɨ													
pEɨ'													
mEɨ													
fEɨ													
vEɨ													
tEɨ													
tEɨ'													
nEɨ			nɥo										
lEɨ		lɥe	lɥo								lɥən		
tsEɨ													
tsEɨ'													
sEɨ													
tʂEɨ													
tʂEɨ'													
ʂEɨ													
ɾEɨ													
kEɨ	tɕʷa	tɕʷe	tɕʷo							tɕʷan	tɕʷən		
kEɨ'	tɕʷ'a	tɕʷ'e	tɕʷ'o							tɕʷ'an	tɕʷ'ən		
ŋEɨ													
xEɨ	ɕʷa	ɕʷe	ɕʷo							ɕʷan	ɕʷən		
Eɨ		ɥe	ɥo							ɥan	ɥən		

Harbin

Harbin Table 1 Syllables headed by plain consonants

	E	ɨ	ə	a	əE	əɨ	aE	aɨ	ən	əŋ	an	aŋ
p	pi	pu	pɤ	pa			paj	paw	pən	pəŋ	pan	paŋ
p'	p'i	p'u	p'ɤ	p'a			p'aj	p'aw	p'ən	p'əŋ	p'an	p'aŋ
m	mi	mu	mɤ	ma			maj	maw	mən	məŋ	man	maŋ
f		fu	fɤ	fa					fən	fəŋ	fan	faŋ
v		vu	vɤ	va			vaj			vəŋ	van	vaŋ
t	ti	tu	tɤ	ta	$t^{w}ej$	təw	taj	taw	tən	təŋ	tan	taŋ
t'	t'i	t'u	t'ɤ	t'a	t^{w}'ej	t'əw	t'aj	t'aw	t'ən	t'əŋ	t'an	t'aŋ
n	ni	nu	nɤ	na		nəw	naj	naw	nən	nəŋ	nan	naŋ
l	li	lu	lɤ	la		ləw	laj	law	lən	ləŋ	lan	laŋ
ʦ	ʦɿ	ʦu	ʦɤ	ʦa	$ʦ^{w}ej$	ʦəw	ʦaj	ʦaw	ʦən	ʦəŋ	ʦan	ʦaŋ
ts'	ts'ɿ	ts'u	ts'ɤ		ts^{w}'ej	ts'əw	ts'aj	ts'aw			ts'an	ts'aŋ
s	sɿ	su	sɤ		$s^{w}ej$	səw	saj	saw	sən	səŋ	san	saŋ
ʈʂ	ʈʂʅ	ʈʂu	ʈʂɤ	ʈʂa	$ʈʂ^{w}ej$	ʈʂəw	ʈʂaj	ʈʂaw	ʈʂən	ʈʂəŋ	ʈʂan	ʈʂaŋ
ʈʂ'	ʈʂ'ʅ	ʈʂ'u	ʈʂ'ɤ		$ʈʂ^{w}$'ej	ʈʂ'əw	ʈʂ'aj	ʈʂ'aw	ʈʂ'ən	ʈʂ'əŋ	ʈʂ'an	ʈʂ'aŋ
ʂ	ʂʅ	ʂu	ʂɤ		$ʂ^{w}ej$	ʂəw	ʂaj	ʂaw	ʂən	ʂəŋ	ʂan	ʂaŋ
r	rʅ	ru	rɤ		$r^{w}ej$	rəw		raw	rən	rəŋ	ran	raŋ
k	ʨi	ku	kɤ	ka	$k^{w}ej$	kəw	kaj	kaw	kən	kəŋ	kan	kaŋ
k'	ʨ'i	k'u	k'ɤ	k'a	k^{w}'ej	k'əw	k'aj	k'aw	k'ən	k'əŋ	k'an	k'aŋ
ŋ						ŋəw			ŋən			
x	çi	xu	xɤ	xa	$x^{w}ej$	xəw	xaj	xaw	xən	xəŋ	xan	xaŋ
0	i		ɤ	a			aj	aw			an	aŋ

Harbin Table 2 Syllables headed by consonants with palatalization

	E	ɨ	ə	a	əE	əɨ	aE	aɨ	ən	əŋ	an	aŋ
p^{E}			p^{j}e					p^{j}aw	p^{j}ən	p^{j}əŋ	p^{j}an	
p$^{E'}$			p^{j}'e					p^{j}'aw	p^{j}'ən	p^{j}'əŋ	p^{j}'an	
m^{E}			m^{j}e					m^{j}aw	m^{j}ən	m^{j}əŋ	m^{j}an	
f^{E}												
v^{E}												
ʈ^{E}			ʈ^{j}e			ʈ^{j}əw		ʈ^{j}aw		ʈ^{j}əŋ	ʈ^{j}an	
ʈ$^{E'}$			ʈ^{j}'e					ʈ^{j}'aw		ʈ^{j}'əŋ	ʈ^{j}'an	
n^{E}		nü	n^{j}e			n^{j}əw			n^{j}ən	n^{j}əŋ	n^{j}an	n^{j}aŋ
l^{E}		lü	l^{j}e	l^{j}a		l^{j}əw		l^{j}aw	l^{j}ən	l^{j}əŋ	l^{j}an	l^{j}aŋ
ʦ^{E}												
ts$^{E'}$												
s^{E}												
ʈʂ^{E}												
ʈʂ$^{E'}$												
ʂ^{E}												
r^{E}												
k^{E}		ʨü	ʨe	ʨa		ʨəw		ʨaw	ʨən	ʨəŋ	ʨan	ʨaŋ
k$^{E'}$		ʨ'ü	ʨ'e	ʨ'a		ʨ'əw		ʨ'aw	ʨ'ən	ʨ'əŋ	ʨ'an	ʨ'aŋ
ŋ^{E}												
x^{E}		ɕü	ɕe			ɕəw		ɕaw	ɕən	ɕəŋ	ɕan	ɕaŋ
E		ü	je	ja		jəw		jaw	jən	jəŋ	jan	jaŋ

Harbin Table 3 Syllables headed by consonants with labialization

	E	ɨ	ə	a	əE	əɨ	aE	aɨ	ən	əŋ	an	aŋ
pᶤ												
pᶤ'												
mᶤ												
fᶤ												
vᶤ												
tᶤ			tʷɤ		tʷej				tʷən	tʷəŋ	tʷan	
tᶤ'			tʷ'ɤ		tʷ'ej				tʷ'ən	tʷ'əŋ	tʷ'an	
nᶤ	nü		nʷɤ									
lᶤ	lü		lʷɤ						lʷən			
ʦᶤ			ʦʷɤ	ʦʷa	ʦʷej				ʦʷən	ʦʷəŋ	ʦʷan	
tsᶤ'			tsʷ'ɤ		tsʷ'ej				tsʷ'ən	tsʷ'əŋ	tsʷ'an	
sᶤ			sʷɤ	sʷa	sʷej				sʷən	sʷəŋ	sʷan	
ʈʂᶤ			ʈʂʷɤ	ʈʂʷa	ʈʂʷej		ʈʂʷaj		ʈʂʷən	ʈʂʷəŋ	ʈʂʷan	ʈʂʷaŋ
ʈʂᶤ'			ʈʂʷ'ɤ		ʈʂʷ'ej		ʈʂʷ'aj		ʈʂʷ'ən	ʈʂʷ'əŋ	ʈʂʷ'an	ʈʂʷ'aŋ
ʂᶤ			ʂʷɤ	ʂʷa	ʂʷej		ʂʷaj				ʂʷan	ʂʷaŋ
rᶤ					rʷej						rʷan	
kᶤ	ʨü		kʷɤ	kʷa	kʷej		kʷaj		kʷən	kʷəŋ	kʷan	kʷaŋ
kᶤ'	ʨ'ü		kʷ'ɤ	kʷ'a	kʷ'ej		kʷ'aj		kʷ'ən	kʷ'əŋ	kʷ'an	kʷ'aŋ
ŋᶤ												
xᶤ	ɕü		xʷɤ	xʷa	xʷej		xʷaj		xʷən	xʷəŋ	xʷan	xʷaŋ
ɨ	ü								wən	wən		

Harbin Table 4 Syllables headed by consonants with palatalization and labialization

	E	ɨ	ə	a	əE	əɨ	aE	aɨ	ən	əŋ	an	aŋ
$p^{Eɨ}$												
$p^{Eɨ'}$												
$m^{Eɨ}$												
$f^{Eɨ}$												
$v^{Eɨ}$												
$t^{Eɨ}$												
$t^{Eɨ'}$												
$n^{Eɨ}$			$n^{ɥ}e$									
$l^{Eɨ}$			$l^{w}e$									
$ts^{Eɨ}$												
$ts^{Eɨ'}$												
$s^{Eɨ}$												
$tʂ^{Eɨ}$												
$tʂ^{Eɨ'}$												
$ʂ^{Eɨ}$												
$r^{Eɨ}$												
$k^{Eɨ}$			$ʨ^{w}e$						$ʨ^{w}ən$	$ʨ^{w}əŋ$	$ʨ^{w}an$	
$k^{Eɨ'}$			$ʨ^{w'}e$						$ʨ^{w'}ən$	$ʨ^{w'}əŋ$	$ʨ^{w'}an$	
$ŋ^{Eɨ}$												
$x^{Eɨ}$			$ɕ^{w}e$						$ɕ^{w}ən$	$ɕ^{w}əŋ$	$ɕ^{w}an$	
Eɨ			ɥe						ɥən	ɥəŋ	ɥan	

Chengde

Chengde Table 1 Syllables headed by plain consonants

	E	O	ɵ	a	əE	əO	aE	aO	pən	pəŋ	an	aŋ
p	pi	pu	pɤ	pa	pej		paj	paw	p'ən	p'əŋ	pan	paŋ
p'	p'i	p'u	p'ɤ	p'a	p'ej		p'aj	p'aw	mən	məŋ	p'an	p'aŋ
m	mi	mu	mɤ	ma	mej	mow	maj	maw	fən	fəŋ	man	maŋ
f		fu	fɤ	fa	fej	fow				ʦəŋ	fan	faŋ
t	ti	tu	tɤ	ta		tow	taj	taw		t'əŋ	tan	taŋ
t'	t'i	t'u	t'ɤ	t'a		t'ow	t'aj	t'aw		nəŋ	t'an	t'aŋ
n	ni	nu		na	nej		naj	naw		ləŋ	nan	naŋ
l	li	lu	lɤ	la	lej	low	laj	law	ʦən	ʦəŋ	lan	laŋ
ʦ	ʦɿ	ʦu	ʦɤ	ʦa	ʦej	ʦow	ʦaj	ʦaw		ts'əŋ	ʦan	ʦaŋ
ts'	ts'ɿ	ts'u	ts'ɤ	ts'a		ts'ow	ts'aj	ts'aw		səŋ	ts'an	ts'aŋ
s	sɿ	su	sɤ	sa		sow	saj	saw	ʈʂən	ʈʂəŋ	san	saŋ
ʈʂ	ʈʂʅ	ʈʂu	ʈʂɤ	ʈʂa		ʈʂow	ʈʂaj	ʈʂaw	ʈʂ'ən	ʈʂ'əŋ	ʈʂan	ʈʂaŋ
ʈʂ'	ʈʂ'ʅ	ʈʂ'u	ʈʂ'ɤ	ʈʂ'a		ʈʂ'ow	ʈʂ'aj	ʈʂ'aw	ʂən	ʂəŋ	ʈʂ'an	ʈʂ'aŋ
ʂ	ʂʅ	ʂu	ʂɤ	ʂa		ʂow	ʂaj	ʂaw	ʐən	ʐəŋ	ʂan	ʂaŋ
ʐ	ʐʅ	ʐu	ʐɤ			ʐow		ʐaw	kən	kəŋ	ʐan	ʐaŋ
k	ʨi	ku	kɤ	ka	kej	kow	kaj	kaw	k'ən	k'əŋ	kan	kaŋ
k'	ʨ'i	k'u	k'ɤ	k'a		k'ow	k'aj	k'aw	ŋən		k'an	k'aŋ
ŋ			ŋɤ			ŋow	ŋaj	ŋaw	xən	xəŋ	ŋan	
x	ɕi	xu	xɤ	xa	xej	xow	xai	xaw			xan	xaŋ
0	j			a		ow	ai					aŋ

Chengde Table 2 Syllables headed by consonants with palatalization

	E	O	ə	a	əE	əO	aE	aO	pən	pəŋ	an	aŋ
p^{E}			pʲe					pʲaw	pʲən	pʲəŋ	pʲan	
$p^{E'}$			pʲ'e					pʲ'aw	pʲ'ən	pʲ'əŋ	pʲ'an	
m^{E}			mʲe					mʲaw	mʲən	mʲəŋ	mʲan	
f^{E}												
t^{E}			tʲe			tʲow		tʲaw		tʲəŋ	tʲan	
$t^{E'}$			tʲ'e					tʲ'aw		tʲ'əŋ	tʲ'an	
n^{E}		nü	nʲe			nʲow		nʲaw		nʲəŋ	nʲan	nʲaŋ
l^{E}		lü	lʲe			lʲow		lʲaw	lʲən	lʲəŋ	lʲan	lʲaŋ
ts^{E}												
$ts^{E'}$												
s^{E}												
$ʈʂ^{E}$												
$ʈʂ^{E'}$												
$ʂ^{E}$												
$ʐ^{E}$												
k^{E}		kü	tɕe	tɕa		tɕow		tɕaw	tɕən	tɕəŋ	tɕan	tɕaŋ
$k^{E'}$		k'ü	tɕ'e	tɕ'a		tɕ'ow		tɕ'aw	tɕ'ən	tɕ'əŋ	tɕ'an	tɕ'aŋ
$ŋ^{E}$												
x^{E}		xü	ɕe	ɕa		ɕow		ɕaw	ɕən	ɕəŋ	ɕan	ɕaŋ
E		ü	je	ja		jow		jaw	jən	jəŋ	jan	jaŋ

Chengde Table 3 Syllables headed by consonants with labialization

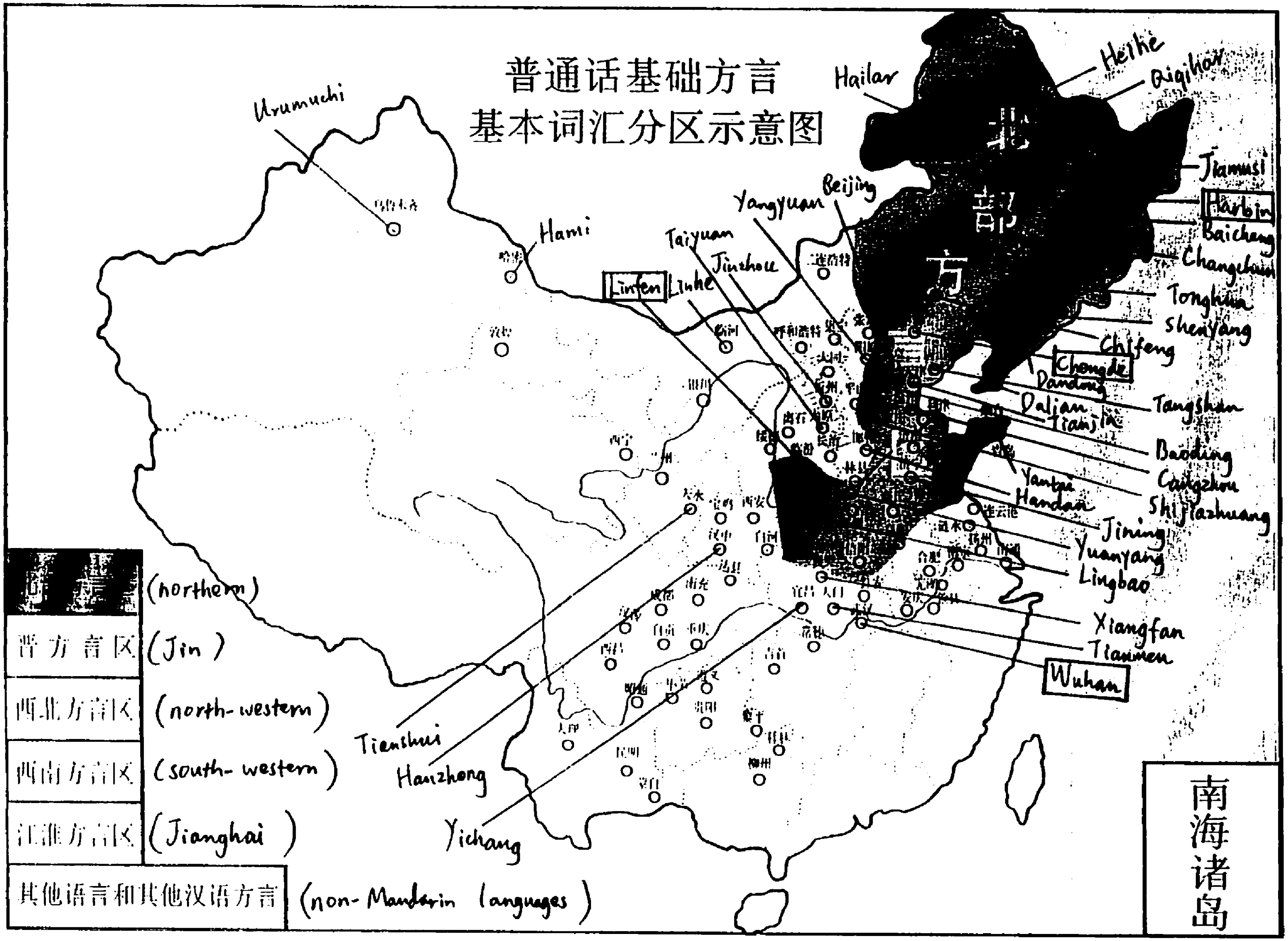
	E	O	ə	a	əE	əO	aE	aO	pən	pəŋ	an	aŋ
p^{O}												
$p^{O'}$												
m^{O}												
f^{O}												
t^{O}			tʷo		tʷej				tʷən	tʷəŋ	tʷan	
$t^{O'}$			tʷ'o		tʷ'ej				tʷ'ən	tʷ'əŋ	tʷ'an	
n^{O}	nü		nʷo						nʷən	nʷəŋ	nʷan	
l^{O}	lü		lʷo						lʷən	lʷəŋ	lʷan	
$ʦ^{O}$			ʦʷo		ʦʷej				ʦʷən	ʦʷəŋ	ʦʷan	
$ts^{O'}$			tsʷ'o		tsʷ'ej				tsʷ'ən	tsʷ'əŋ	tsʷ'an	
s^{O}			sʷo		sʷej		sʷaj		sʷən	sʷəŋ	sʷan	
$ꭧ^{O}$			ꭧʷo	ꭧʷa	ꭧʷej		ꭧʷaj		ꭧʷən	ꭧʷəŋ	ꭧʷan	ꭧʷaŋ
$ꭧ^{O'}$			ꭧʷ'o		ꭧʷ'ej		ꭧʷ'aj		ꭧʷ'ən	ꭧʷ'əŋ	ꭧʷ'an	ꭧʷ'aŋ
$ʂ^{O}$			ʂʷo	ʂʷa	ʂʷej		ʂʷaj		ʂʷən		ʂʷan	ʂʷaŋ
$ʐ^{O}$			ʐʷo		ʐʷej				ʐʷən	ʐʷəŋ	ʐʷan	
k^{O}	kü		kʷo	kʷa	kʷej		kʷaj		kʷən	kʷəŋ	kʷan	kʷaŋ
$k^{O'}$	k'ü		kʷ'o	kʷ'a	kʷ'ej		kʷ'aj		kʷ'ən	kʷ'əŋ	kʷ'an	kʷ'aŋ
$ŋ^{O}$												
x^{O}	xü		xʷo	xʷa	xʷej		xʷaj		xʷən	xʷəŋ	xʷan	xʷaŋ
O	ü		wo	wa	wej		waj		wən	wəŋ	wan	waŋ

Chengde Table 4 Syllables headed by consonants with palatalization and labialization

	E	O	ə	a	əE	əO	aE	aO	pən	pəŋ	an	aŋ
p^{EO}												
$p^{EO'}$												
m^{EO}												
f^{EO}												
t^{EO}												
$t^{EO'}$												
n^{EO}			nɥe									
l^{EO}			lɥe									
ts^{EO}												
$ts^{EO'}$												
s^{EO}												
$tʂ^{EO}$												
$tʂ^{EO'}$												
$ʂ^{EO}$												
$ʐ^{EO}$												
k^{EO}			$ʨ^{w}e$						$ʨ^{w}ən$	$ʨ^{w}əŋ$	$ʨ^{w}an$	
$k^{EO'}$			$ʨ^{w'}e$						$ʨ^{w'}ən$	$ʨ^{w'}əŋ$	$ʨ^{w'}an$	
$ŋ^{EO}$												
x^{EO}			$ɕ^{w}e$						$ɕ^{w}ən$	$ɕ^{w}əŋ$	$ɕ^{w}an$	
EO			ɥe						ɥən	ɥəŋ	ɥan	

Appendix 3

The following map shows the five subgroups of Mandarin. Each language included in the study is indicated. In particular, the four languages, Wuhan, Linfen, Chengde, and Harbin, are shown in box.


普通话基础方言
基本词汇分区示意图
北部方
(northern)
晋方言区 (Jin)
西北方言区 (north-western)
西南方言区 (south-western)
江淮方言区 (Jianghai)
其他语言和其他汉语方言 (non-Mandarin languages)
南海诸岛
Urumuchi
Hami
Hailar
Heihe
Qiqihar
Jiamusi
Harbin
Baicheng
Changchun
Tonghua
Shenyang
Chifeng
Chengde
Dandong
Dalian
Tianjin
Tangshan
Baoding
Cangzhou
Shijiazhuang
Yantai
Handan
Jining
Yuanyang
Lingbao
Xiangfan
Tianmen
Wuhan
Beijing
Yangyuan
Taiyuan
Jinzhou
Linfen
Linhe
Tianshui
Hanzhong
Yichang