THE PHONOLOGICAL DOMAIN OF TONE IN CHINESE: HISTORICAL PERSPECTIVES

by

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ii

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Abstract

This thesis demonstrates how autosegmental licensing theory operates in Chinese. Autosegmental licensing works on the basis that the domain of tone in Chinese is the whole syllable that includes both the sonorant (tone-bearing units) and the obstruent (non-tone-bearing units). A syllable contains two licensers with the syllable node as a primary licenser and the coda a secondary licenser. The syllable as a licenser functions in its licensing domain that includes all the segmental features borne by the onset and the nucleus and the tonal features of the tone that is associated with the nucleus vowel. The coda as a secondary licenser also functions in its licensing domain that includes all the segmental features borne by the coda segment and the tonal features of the tone associated with the coda segment which has to be a sonorant. The interaction between consonants and tones takes place within each licensing domain in that the segmental features licensed by the licenser will interfere with the tonal behaviour. In the autosegmental licensing, not only the relationship between syllable types and the tonal status of the syllables can be predicted, but also the tonal changes including tonogenesis, tonal split and merger are fully accounted for.

Acknowledgements

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Table of contents

Chapter One

Introduction

In Chinese, the phonological domain of tone is the whole syllable[1], which not only includes nucleus vowels and coda sonorants that are regarded as tone-bearing units traditionally, but also includes onset consonants and coda obstruents, which play an important role in tonal development though they do not bear a tone phonetically. This hypothesis coincides with the autosegmental licensing that also acknowledges the syllable as the tonal domain.

In the licensing theory, a syllable may have two licensers, with the syllable node as a primary licenser and the coda node as a secondary licenser. A licenser not only licenses all the segmental features, it also licenses tonal features. A licenser is able to pass all the information from the segmental tier to the tonal tier. As a result, in the licensing domain, the relevant segmental feature licensed will determine the tonal feature assigned to the licensed tone.

The syllable node as a licenser is obligatory in all languages, while the coda's licensing status is language dependent. In Chinese, the syllable always licenses a tone(s) that is associated with the nucleus vowel. The coda node only licenses a tone when it contains a sonorant. This chapter will discuss how autosegmental licensing operates in Modern Chinese.

1.1 Syllable structure and tone in Chinese

In this section, the syllable structure, the tone and the relationship between tones and different types of syllable will be discussed.

Modern Chinese has a uniform syllable structure across all dialects (Duanmu, 1990). Traditionally, it is shown as the following: (1).

$$\text{Tone}$$

$$\text{(C) (G) V } (\begin{Bmatrix} G \\ C \\ N \end{Bmatrix})$$

Each syllable carries a lexical tone. In the syllable, C and G can be any consonant or glide at the prevocalic position. The postvocalic position is highly restricted in that the postvocalic G can only be either [-j] or

[-w]; and the postvocalic C is a voiceless stop ([-p],[-t],[-k], [-ʔ]), and the postvocalic N is a nasal ([-m], [-n], [-ŋ]. 16 syllable types[2] can be derived from (1).

Conventionally, a Chinese syllable is divided into an Initial that contains the prevocalic C and a Final that includes the rest part of the syllable. A hierarchical representation of the syllable structure of Mandarin is given by Cheng (1973) :

(2).

tone				
initial	final			
	medial	rhyme		
		nucleus	ending	
			vocalic ending	consonantal ending

This way of breaking a syllable down into an initial and a final can be traced back to as early as the 6th century A.D. when scholars used a method called "fanqie" to spell a word. They used the initial part of a word and the final part of another to spell out the sound of a third word. For example: tone + pan -> tan. The tone of the target syllable is indicated by the syllable that contributes the final part. The tone was regarded as a feature borne by the final part of the syllable at that time.

Though this structure is for Mandarin, it can be expanded to all varieties[3] of Chinese by adding the voiceless stop ending to the coda position:

(3).

```
                syllable
              /          \
         initial          final
                        /        \
                   medial         rhyme
                                 /      \
                            nucleus      coda
```
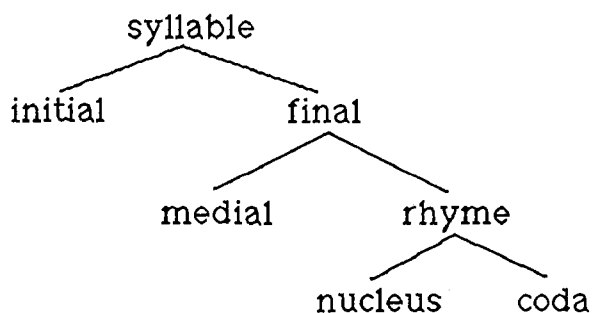
Compared with a more commonly cited syllable structure as illustrated by Goldsmith (1990), we find that the medial, a prevocalic glide in a Chinese syllable, has no place in the following structure:

(4).

```
                    Syllable
                   /        \
              onset          rhyme
                            /      \
                       nucleus      coda
```
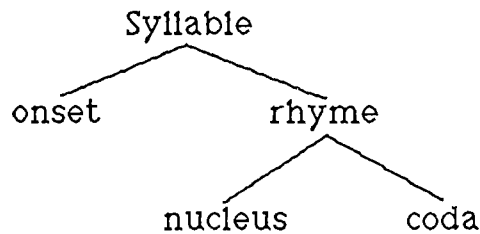
In (3) the onset consists of only one consonant. The prevocalic glide is assigned to the medial. In (4) any prevocalic segment, no matter how many there are, can all be taken by the onset. If we want (4) to be adapted to Chinese as well, we will have to determine where the medial belongs.

First of all, the medial cannot be part of the rhyme. This is shown by the structure that the medial is outside the rhyme. Besides, in ancient poetry, syllables were considered to rhyme when the nucleus vowel and the unit following the vowel were the same. So an, tyan, swan, etc. would rhyme so long they shared the same rhyme and tone.

We assume that the medial is part of the onset. The problem is whether the CG- should be regarded as a single consonant plus a secondary articulation in the form of C^G-[4] as suggested by Duanmu (1990) in (5) a) or they are two elements in a branching onset as in (5) b):

(5).

a).
```
          syllable
         /        \
      onset       rhyme
        |         /    \
        |      nucleus  coda
        |        |       |
        tʸ       a       n
```

b).
```
          syllable
         /        \
      onset       rhyme
      /  \        /    \
     /    \    nucleus  coda
    /      \     |       |
    t       y    a       n
```
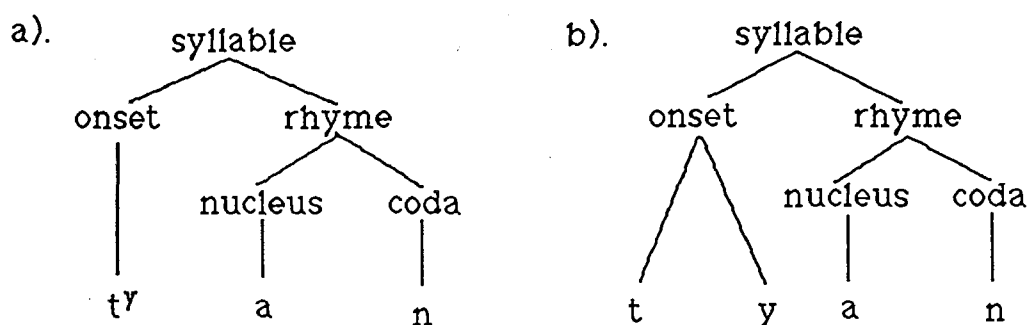
Duanmu's argument is for a syllable in Chinese to have just three slots with each filled with one segment. From a historical point of view, both the onset and coda once contained more than one segment (Guo 1986, Yan 1980, Hu 1980, Xu 1980, etc.). It is not possible to treat all the consonant clusters as a single consonant plus a secondary articulation. Therefore, we assume that both the onset and the coda can branch as in (5) b) above.

In middle Chinese (after 800 A.D.), there were four tonal categories: Tone I (平), Tone II (上), Tone III (去) and Tone IV (入)[5], which in English are called the Level Tone, the Rising Tone, the Departing Tone and the Entering Tone. The syllables in the first three tones ended in a sonorant, either a glide or a nasal. Tone I-III contrasted in tonal patterns[6]. But Tone IV, with the voiceless stop ending still present in the syllable had not developed a tonal pattern. It was distinct by its segmental features. Mei (1970a) argues that it was short and had an uncertain tonal pattern as one can see from the evidence found in Modern Chinese varieties.
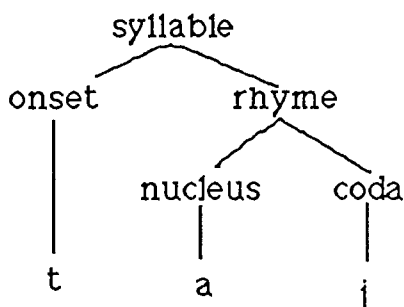
In marking a lexical tone in Modern Chinese, it is most convenient to use the system of tone letters first used by Chao

(1930). Digits 1-5 are used to indicate both the pitch height and the length[7]. In most cases, a lexical tone is represented with two digits, e.g. 22, 53, 24, etc. Some tone values are transcribed with a sequence of three digits, e.g. 214, 331, etc. But for Tone IV syllables, only one digit is used. The major difference between the first three tones and Tone IV is not length difference. Rather, Tone IV category is still characterized by its voiceless stop ending, because in this type of syllables only the underlying tone associated with the nucleus vowel can surface at the phonetic level. We will propose in the next section that only when the coda also associates a sonorant and licenses a tone can a lexical tone be formed. Compared with the development of Tone I, Tone II and Tone III, which also underwent a stage when the obstruent ending drops and the syllable acquires a tonal pattern as its primary distinctive feature, it is quite likely that Tone IV is on the same track but has not completed this process yet. That is why the Tone IV syllable in modern Chinese is short and does not have a lexical tone.

When a syllable either ends in a glide, or a nasal, the syllable will have a lexical tone, which requires at least two underlying tones associated with both the nucleus and coda to be licensed in order to form a lexical tone phonetically.

(6).

a).

```
              syllable
            /          \
        onset          rhyme
          |           /      \
          |       nucleus    coda
          |          |         |
          t          a         j
```

b).

```
              syllable
            /          \
        onset          rhyme
          |           /      \
          |       nucleus    coda
          |          |         |
          t          a         n
```
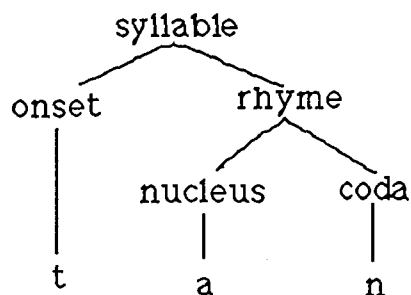
In (6) both syllables [taj] ('Mrs') and [tan] ('charcoal') carry a lexical tone because the coda is occupied by a sonorant, which is able to associate an underlying unit tone.

If a syllable only has a vowel in the nucleus like [ta] ('he/ she') we assume that the nucleus vowel fills both the nucleus and the coda by a multi-association.

c).

```
              syllable
            /          \
        onset          rhyme
          |           /      \
          |       nucleus    coda
          |          |       /
          t          a ─────
```
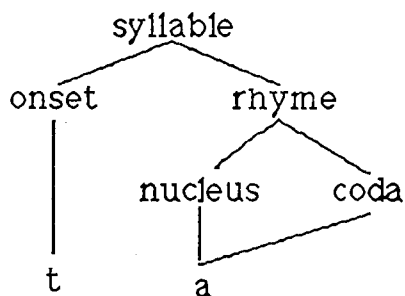
(6) c). above indicates a vowel spreading process, where a single vowel occupies both the nucleus and the coda. The evidence comes from 1) that there is no length difference among syllables of VN, VG and V types; 2) that syllable type VC which is indicated with one digit is obviously shorter than V that is marked with at least two

digits; and 3) that Woo's measurement of the duration of syllables in Mandarin (in CSEC) supports this assumption, too (Woo, 1969).

(7).

syllable	vowel	coda	total
ba	34	-	34
ban	21	15	36
pang	21	15	36
bei	33	-	33
ma	36	-	36
mai	36	-	36
man	23	19	42
mang	23	15	38
mi	34	-	34
min	20	14	34

From the above figures we see that as far as the duration is concerned, syllables with a single nucleus vowel are almost as long as syllables with both a vowel and glide ([ma]-36/ [maj]-36); or with a vowel and a nasal ([mi]-34/ [min]-34).

To sum up, in Chinese, the tonal status of a syllable is partially determined by the syllable type. When the coda contains a voiceless stop, the syllable does not have a lexical tone. If a syllable only contains a nucleus vowel, the vowel will spread over to the coda so that the coda will contain a sonorant. When the coda is filled with a sonorant and associated with a tone, in addition to

the tone associated with the nucleus vowel a lexical tone is phonetically realized.

1.2. Licensing
1.2.1. Autosegmental Approach

The autosegmental approach to the phonology of tone has the following advantages over other schools. First of all, tone is treated as a suprasegmental, and a separate part of the lexical entry for each morpheme (Yip 1980). There is a relationship of simultaneity in time between the segment and tone. In an autosegmental phonology representation, there are two or more tiers of "segments". Segments are represented on a segmental tier, which only specifies segmental features, and tones are represented on a tonal tier that only specifies tonal features, as in

(8).

```
segmental     b u l u      or      [+syll] [-syll] [+syll]
                |   |                   |               |
tonal         H H                  [+High]        [+High]
```

(Goldsmith 1990:9)

In this type of representation, "each tier represents a sequence of gestures (viewed from an articulatory point of view) or distinctive acoustic transitions (viewed from an acoustic point of view)" (Goldsmith 1990). At a later stage, an association line will link the elements from both tiers to show "which tone or tones are produced

at the same time as each of the vowels are produced" (p.10).

Secondly, autosegmental phonology treats contour tones as sequences of unit level tones. Contours are seen as composed of sequences of level tones marking each level with a feature (Goldsmith

1976, 1990, Yip 1980, etc.). Wang (1967), by contrast, uses unit contour features like [±rising], [±falling] to represent a contour tone. Autosegmentalist, unlike Wang, for example, would represent a rising tone as LH and a falling tone as HL, where H marks a high tone and L a low tone. The actual phonetic value of H or L is not significant any more than the actual value of backness of the feature [+back] in an English /u/. What matters is the pattern the features form. The interpretation of the lexical tone will be determined by the number of underlying unit tones associated in the syllable and their features. A Mandarin Tone 3 syllable (developed from Middle Chinese Rising tone (Tone II)) is a low falling-rising tone (Hu, 1985). It has the pitch pattern 214 according to Chao's pitch system. This tone is represented as LH. The 21 sequence is represented by an L feature, as both represent a low tone. The 21 difference is largely based on phonetic perception, which is not phonologically significant. For more arguments, see Yip (1980). This autosegmental approach to tones is significant in that it can account for the interaction between consonants and tones when only part of the tone is involved. In Yip's words, this method (sequence of level tones) can solve problems "that involve necessary reference to the component tones" (p.8). We will come back to this in Chapter Three and Four.

1.2.2. Licensing theory

In Goldsmith's autosegmental licensing theory, "the essence of the idea of autosegmental licensing is that there are prosodic units that

are licensers -- the syllable node as a primary licenser, and the coda node and certain word-final morphemes as secondary licensers. A licenser is endowed by the grammar of the language with the ability to license a set of phonological features-- or more precisely, autosegments,...". "A given licenser can license no more than one occurrence of the autosegment in question. This unique licensing can be graphically represented in terms of a non-branching path that can be traced from the licenser to the autosegment in question. Finally, in line with the remarks above, all autosegmental material must be licensed at the level we called the W-level, the word-level. Elements not licensed at this level will not proceed to the post-lexical phonology, i.e. are deleted" (p.125). This licensing relationship is shown in the following diagram:

(9).
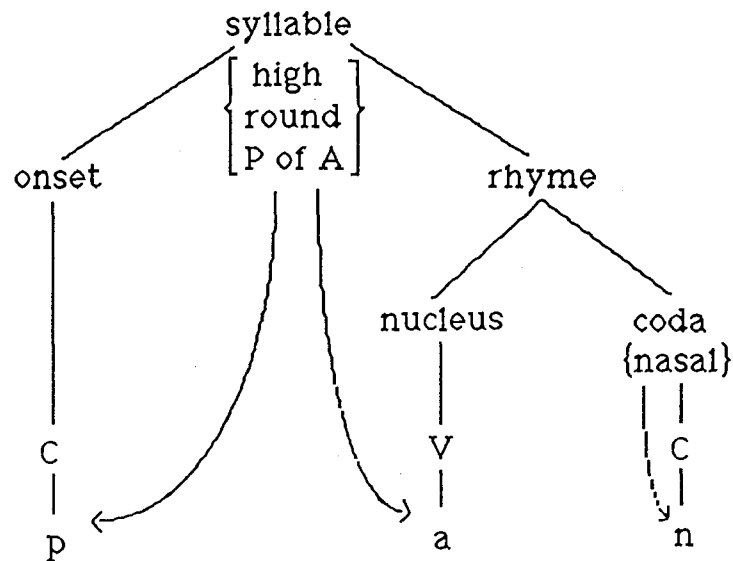
In the syllable structure above, the syllable node as a primary licenser, has the ability to license all of the segmental features and tonal features borne by both the onset and nucleus. In another word, the onset and nucleus belong to the syllable licensing domain. Whether the coda is a secondary licenser or not is language dependent. The feature borne by the coda is never licensed by the syllable, because on the one hand, the "non-branching path" condition of the licensing will not allow the syllable node to license the features from the coda. On the other hand, if the coda is a licenser itself, it will block the syllable licensing. That explains why both synchronically and diachronically the segmental feature of the coda never affects the tone licensed by the syllable. The segmental features licensed by the coda are relevant only to the tone the coda licenses. The two licensers work in their individual licensing domains.

In Chinese, both the syllable and the coda are licensers. The syllable will license both segmental features and tonal features unconditionally. But the coda can only license tonal features under certain conditions.

Taking syllable types as a whole in all Chinese varieties, there are three types of rhyme that are related to tonal status: 1) syllables with a sonorant coda that is either a nasal, or a glide or a vowel by vowel spreading; 2) Tone IV syllables with a voiceless stop coda and 3) neutral tone syllables with a dropped sonorant coda but carrying no lexical tone. Syllables in the first type are found in all varieties. Tone IV syllables are found in those where this category is preserved as in Wu, Yue, Min, Kejia, etc. Neutral tone syllables are mainly found in northern forms of Mandarin.

The syllable with a sonorant coda has the following structure: (10).

a).

```
              syllable
          ____/      \____
      onset            rhyme
        |            __/  \__
        |        nucleus    coda
        |           |         |
        t           a         n

                    H         L
```

b).

```
                    syllable{H}
                ___/        \___
          onset    /           rhyme
            |     /         __/    \__
            |    [ nucleus       coda{L}
            |    \    |            |  |
            t     \   a            n  |
                   \  |               |
                    ↘H              LL
```
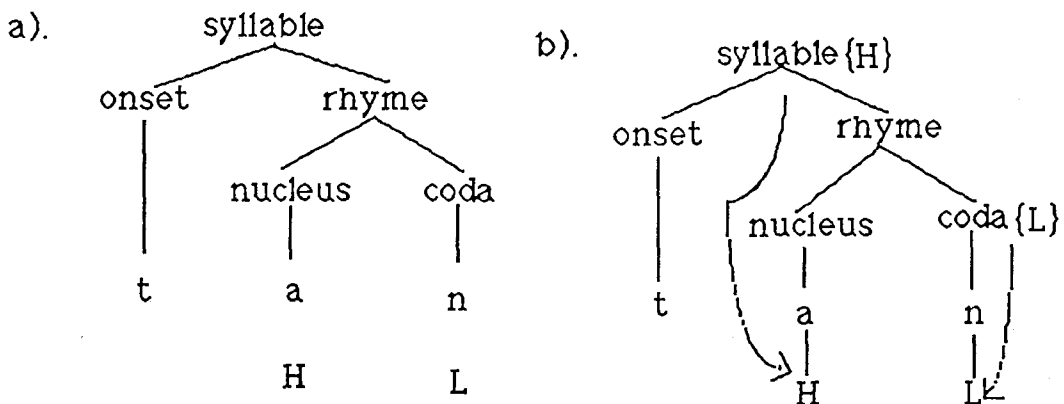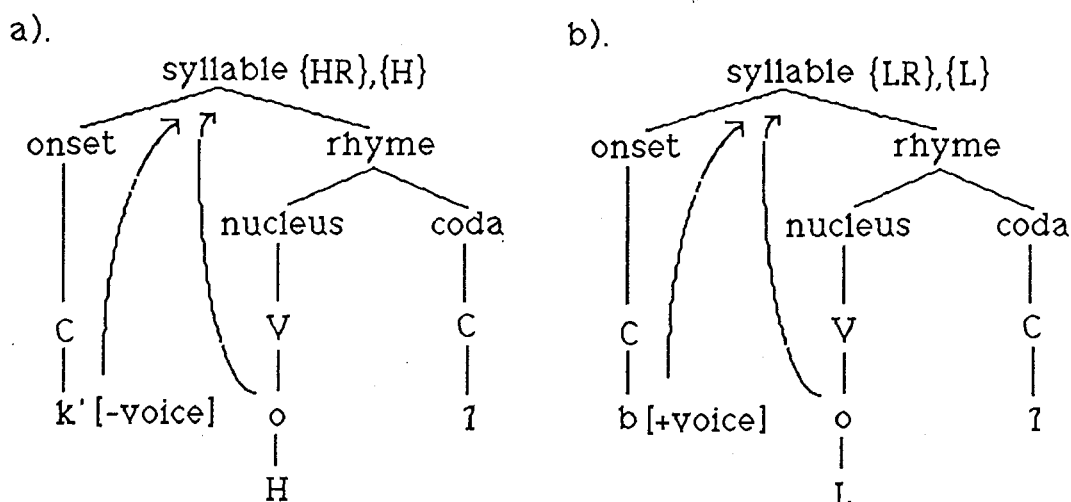
tan('charcoal') are the segments at the segmental tier. H and L are tones at the tonal tier. By applying the Association Convention[8] H is associated with a and L is associated with n. H is in the syllable

licensing domain and L is in the coda licensing domain. When both underlying tones H and L are associated with sonorants and are licensed, they will be realized phonetically forming a lexical falling tone as <u>tan</u> (51) 'charcoal' in Mandarin. In (10) b), the syllable licenses an {H} tone and the coda an {L} tone.

In the case of a Tone IV syllable like [k'oʔ] ('to cry') in Shanghainese, no lexical tone will be formed. Instead, the syllable carries the pitch height, 5 for syllables belonging to the high register and 2 for syllables belonging to the low register. The syllable has the following structure:

(11).

a).

syllable {HR},{H}

```
        onset              rhyme
          |              /       \
          |         nucleus      coda
          |            |          |
          C            V          C
          |            |          |
       k' [-voice]     o          ʔ
                       |
                       H
```

b).

syllable {LR},{L}

```
        onset              rhyme
          |              /       \
          |         nucleus      coda
          |            |          |
          C            V          C
          |            |          |
        b [+voice]     o          ʔ
                       |
                       L
```

The syllable as a licenser will license the segmental features [±voice] from the onset. By the Association Convention, the nucleus vowel is associated with the underlying tone H. As the coda contains a non-sonorant, the association between the glottal stop and the underlying tone is blocked. Therefore, though there might

be two underlying tones in each syllable, only one can be associated with the nucleus vowel and licensed by the syllable, which cannot form a lexical tone.

Tone IV syllables in Shanghainese have two possible pitch heights, 5 and 2. The distribution of the two pitches is determined by the feature [voice] of the onset. If the onset is specified [+voice] as in b), the syllable will license the feature. It will also license an {LR} (Low Register) feature. When the low register feature is licensed, the syllable will license an L tone accordingly, which is associated with the nucleus vowel. As only one tone is licensed, only a pitch height is realized phonetically. In a high register syllable, the feature [-voice] licensed from the onset will make it possible for the syllable as a licenser to license an {HR} (high register feature) and an {H} (high tone feature) associated with the nucleus vowel. The high register syllable marker 5 and the low register marker 2 in Shanghainese are merely phonetic interpretations.

Another example will illustrate this procedure, as well. Neutral tone syllables in Mandarin had a sonorant ending originally. Most of the neutral tone syllables also have their lexical tone version at the lexical level. They become neutral tone syllables in speech when they are unstressed. Neutral tone syllables are not only short, but also they carry no lexical tones. In Mandarin, the pitch height of a neutral tone has to be determined by the tone of its preceding syllable[9]. Woo (1969) has analysed this phenomenon in

terms of how many sonorants are contained in different types of syllables. She suggests that "the total duration of the sonorant cluster, beginning with the main vowel, is determined by the number of sonorants in the syllabic nucleus". In her opinion, the neutral tone syllable contains one sonorant, so it is short, i.e. just like in Shanghainese Tone IV syllables, there is no lexical tone. Tone 3 (214) syllables in Mandarin contains three sonorants so they are longer than syllables in other tones that contain two sonorants. She explains that " in the unstressed syllables, the last part of the sonorant cluster tends to be deleted, that is, if the underlying cluster is a diphthong, the unstressed syllable tends to show a pure vowel as [dej] versus [de] (a particle) in Mandarin; if it is a VN cluster, the unstressed syllable shows a nasalized vowel as [pjan] versus [pjã] ('side'), with no pure nasal band. An underlying long vowel, of course, shows only a short pure vowel in the unstressed syllable" (p.35). The above statement is represented as: (12).

$$[+son] \longrightarrow \emptyset \ / \quad V \quad \underline{\hspace{2cm}}$$
$$[-stress]$$

This relationship between different rhyme type and the tonal status of the syllable can be predicted in the licensing. Before the syllable is reduced to a neutral tone syllable, it has two tones licensed by the syllable and coda respectively, which form a phonetic lexical tone in (13) a) below. When the syllable is unstressed, the coda is deleted in (13) b) below:

(13).

a).
```
              syllable {H}
             /          \
        onset           rhyme
        /  \           /      \
       /    \      nucleus    coda{H}
      C      G       |          |
      |      |       V          N
      P      j       |          |
                     a          n
                     |_____|
                          |
                          H
```
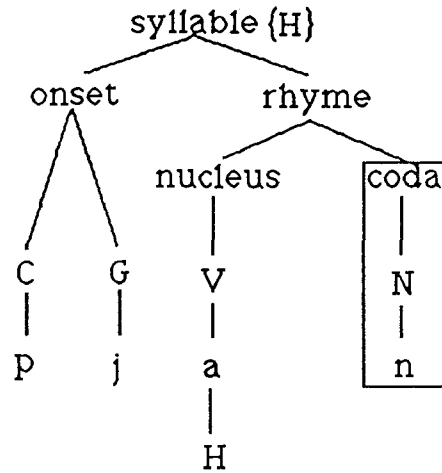
b).
```
              syllable {H}
             /          \
        onset           rhyme
        /  \           /      \
       /    \      nucleus    [coda]
      C      G       |          |
      |      |       V          N
      P      j       |          |
      P      j       a          n
                     |
                     H
```
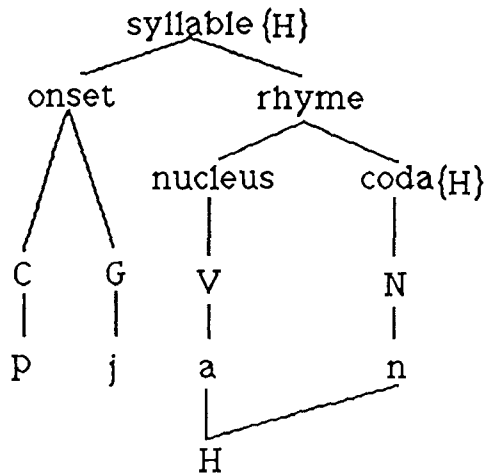
The box indicates the deletion. Any element in the box is deleted. Here, the question is whether the whole coda is deleted or only the segment in the coda is deleted. If only the segment in the coda is deleted, it is possible for the coda to be reassociated with the nucleus vowel by vowel spreading since there is an empty coda. Obviously this does not happen. Therefore, it is the whole coda that is deleted. The H tone that was licensed by the coda before is either dropped with the coda, or, after the coda is deleted, it has no segment to be associated with, so it is also deleted because an unassociated tone can not be realized phonetically. For the neutral tone syllable, the realized tone licensed by the syllable node can only be realized as a pitch height. This pitch height is determined by the tone licensed by the coda in the preceding syllable, a process we will not go into here.

From the above discussion it is concluded that in Chinese, both

the syllable and coda are licensers. The syllable licenses the tone associated with the nucleus vowel. The tonal features licensed by the licenser are determined by the segmental features that are also licensed by the licenser. The coda as a licenser is restricted by the sonority property of the segment in the coda. Only when the coda contains a sonorant that is associated with a tone can the coda license the tone. Underlying tones have to be associated first before they are licensed. If the tone licensed by the syllable is realized phonetically without the coda also licensing a tone, the syllable will not have a lexical tone, instead, it just carries a pitch height.

1.2.3. Number of underlying tones

As is discussed earlier, a lexical tone syllable in Chinese at least needs two underlying tones to be licensed by the two licensers in order for a lexical tone to be formed phonetically. If one tone is licensed, the syllable will carry a pitch height. In the examples given previously, neither a neutral tone syllable nor a Tone IV (Entering Tone) syllable bears a lexical tone because they just have one underlying unit tone licensed in the syllable licensing domain. But what is the maximum number of underlying unit tones that can be licensed?

In Goldsmith's theory, a voiced obstruent is seen as an element to which an L tone can be associated (See Goldsmith 1990:34). In Chinese, only sonorants can be associated with tones. If the onset is

a voiced obstruent, its voice feature is licensed by the syllable node in whose licensing domain the interaction between the segmental feature and the tonal feature occurs, so the tone licensed by the syllable is assigned the L feature.

(14).
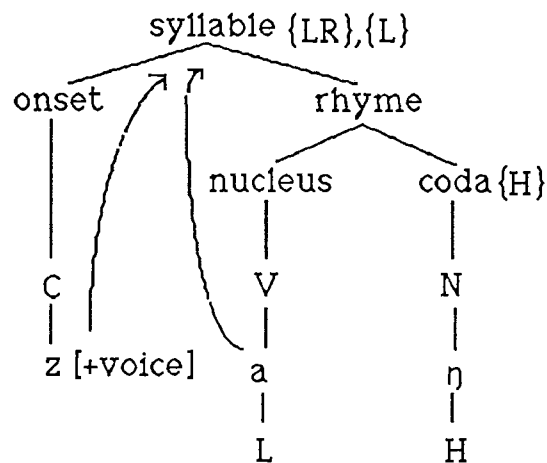
In the Shanghainese word [zaŋ] ('bed') in (14), even though the onset contains a voiced consonant, it does not bear the L tone. In fact, the onset and the nucleus are considered to form one unit. The tone is always associated with the nucleus vowel. The onset [+voice] feature is relevant to the tone associated with the nucleus in that the feature licensed by the syllable also licenses the tone. When the feature is passed to the tone, the tone will be assigned an L feature. As the syllable will also license the {LR} (low register) feature, the whole syllable is realized as carrying an LH tone in the low register.

The number of underlying tones is determined by the sonorants contained in rhymes. If there are three sonorants in the rhyme, they will associate three underlying unit tones. The rhyme contains
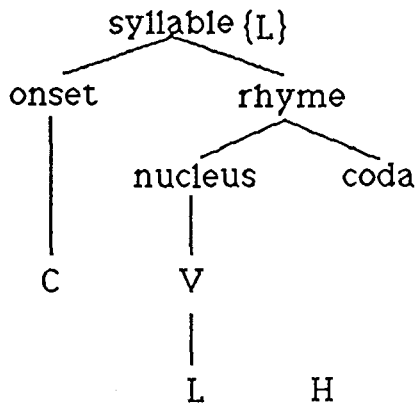
the forms of V, VG, VN or VC (where C is a voiceless stop). For the VC type, it is quite clear that it cannot bear a lexical tone because of the sonority property of the C needed for the association of an underlying unit tone. As to the rest, VG and VN are both eligible to carry a phonetic tone, as the coda is filled with a sonorant. The problem is with the V type. If the V only fills the nucleus part with a null coda just as in the case of a neutral tone, no phonetic tone can be formed with just one underlying tone licensed. As a matter of fact, syllables with a V in the rhyme carry a lexical tone just as the VG or VN types do.

Woo (1969) shows in an experiment that a syllable with a single vowel is the same in duration as syllables with sonorant endings. Though the duration of syllables in different tones may vary a little
due to the tonal influence, there is no dramatic difference between syllables containing a nucleus vowel and syllables with both a nucleus vowel and a sonorant coda. In another experiment, Wang (1987) found the pitch pattern of a lexical tone syllable to be about twice as long as that of a Tone IV (Entering Tone) syllable. Compared with a neutral tone syllable where the coda is deleted, a lexical tone syllable with a vowel is more than twice as long as a neutral tone syllable (Woo 1969).
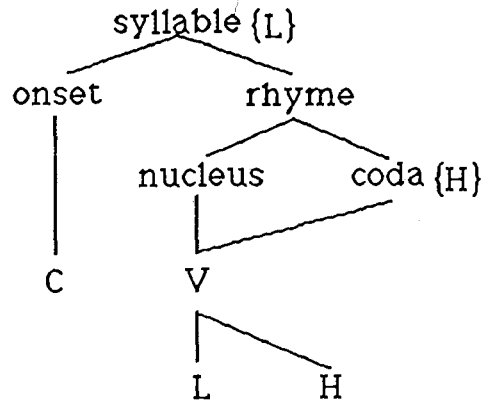
This suggests that underlyingly, the rhyme containing a single vowel actually consists of two sonorant elements. It is a vowel spreading process:

(15).

a).

```
          syllable {L}
         /          \
     onset          rhyme
       |            /    \
       |       nucleus    coda
       |          |
       C          V
                  |
                  L        H
```

b).

```
          syllable {L}
         /          \
     onset          rhyme
       |            /    \
       |       nucleus    coda {H}
       |          |      /
       C          V ────
                 / \
                L   H
```

The vowel spreading is represented by the multi-association of V with both the nucleus and the coda. In the same token, the two underlying tones are also multi-associated with the V which by an interpretation rule is indicated as long. The effect is the same as two underlying tones being associated with both the nucleus and the coda sonorant respectively.

In dealing with tones in Mandarin, Yip (1980) says that "all Mandarin tones might have two tonemes". Yip's toneme is the same as the underlying unit tone here. In the feature representation, Yip uses two letter feature as HH for the high level tone, LH for the rising tone, etc.

(16).

Name	Description	Pitch	Yip's Feature
Tone 1	high level	55	HH
Tone 2	mid rising	35	LH
Tone 3	low falling-rising	214	LL
Tone 4	high falling	51	HL

Here, the phonetic information high, mid, etc. is not phonologically significant because it is the tonal pattern that contrasts. Mandarin Tone 1, 2 and 4 all contain two underlying unit tones, each representing a pitch level. When the tones are represented with two tonal features, they are of approximately the same length. Tone 3 has three underlying tones represented by three digits 214. Though tone 3 in speech is either realized as a 35 tone before another Tone 3 syllable, or a 21 tone before other tone syllables, at the lexical level, it still contains three level tones, and all three levels should be represented. It is not sufficient to put just LL for it. If all three underlying tones should be represented, it has to be determined first how many underlying tones a licenser can license, and which segment can be associated with more than one tone.

Three level tones in tonal representation are found not only in Mandarin, but also found in the following varieties:

(17).

Locations	Three-digit Tones
Jinan	213
Xi'an	453
Hankou	213
Yangzhou	434
Suzhou	513/331
Nanchang	213
Fuzhou	213/242

(Dictionary of Chinese Dialects

(in Chinese)1959)

As three is the maximum number of underlying tones found in Chinese so far, it is assumed that it is the maximum number allowed. If it is so, the licensers in a syllable must be able to license all three of them.

Woo's measurement of Mandarin tones shows that in Mandarin, Tone 1, 2 and 4 are of almost the same duration with Tone 4 slightly shorter. But tone 3 that has three underlying tones is much longer than the others. To cite a few examples we can see that Tone 3 is about one third longer than the other tones (the digits represent the duration in CSEC):

(18).

| Rhyme Types	Examples	Tone 1	Tone 2	Tone 4	Tone 3
-V	ma	34	36	31	˙51
-VN	man	36	42	27	50
-VG	maj	33	34	29	50

For example, ma 'mother' (level), ma 'lily' (rising) and ma 'scold' (falling) are of approximately the same length, while ma 'horse' (falling-rising) is about a third longer than the other tones. The left column represents the rhyme type. Woo (1969) suggests that since the vowel in Tone 3 carries length differences, it should be represented with two vowels in the nucleus. That is, if it is a V in other tones, it will be a VV sequence in Tone 3. This is represented by a branching nucleus in (19):

(19).

a).
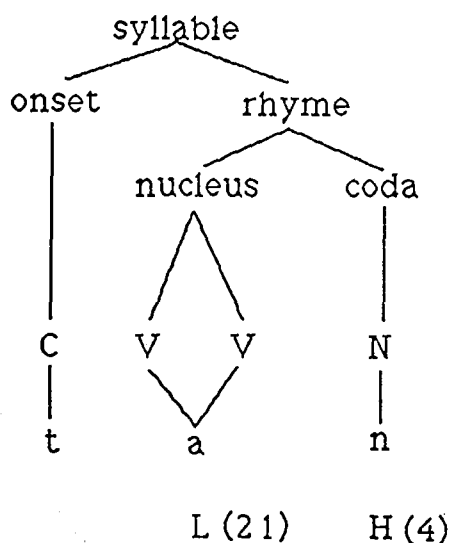
b).
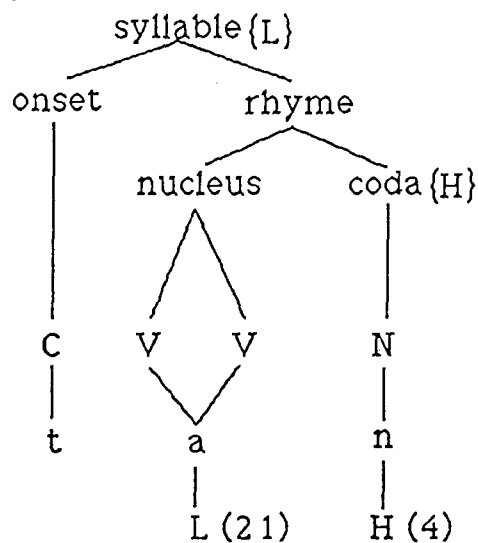
The branching nucleus indicates a long vowel. The pattern of 21 associated with the nucleus is determined by the phonetic interpretation. After the Association Convention is applied, each tone is linked with the sonorants in the syllable and all of them are realized phonetically.

In the case of a CV syllable with a 214 tone, the V spreading still applies. daa ('to hit') , daaj ('to catch') and daan ('to dust') are of the same duration under the same falling-rising (214) tone. This indicates that a CV syllable of Tone 3 actually has three sonorants aaa .

(20).

a).

L (2 1)   H (4)

b).

L (2 1)   H (4)
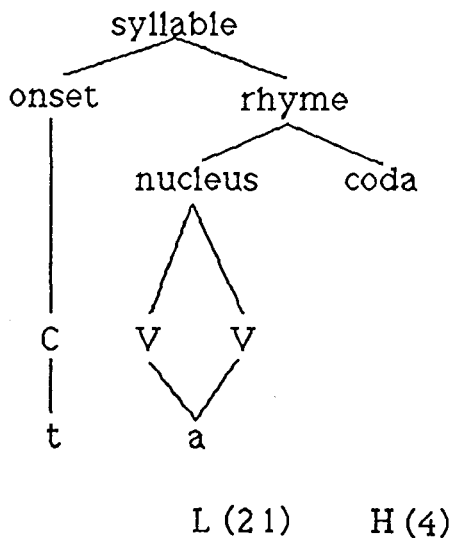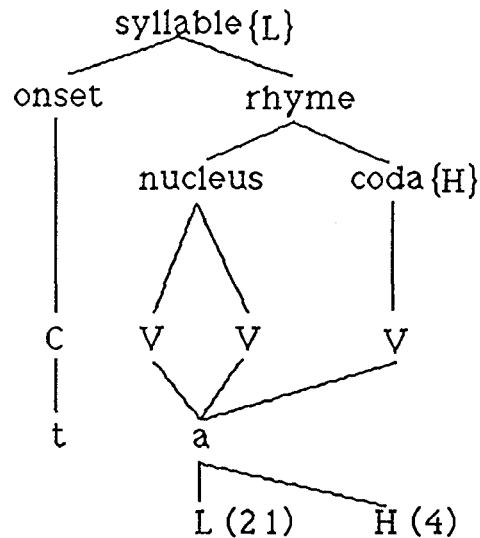
After a is multi-associated with the three sonorants, the three underlying unit tones are also associated with a, with the syllable node licensing the first two tones and the coda the third tone.

When Tone 3 is put in speech, it is either shortened to a 35 tone or a 21 tone by tone sandhi rules. The first one involves some other

change that we are not going to deal with here. For the 21 tone, it can be seen as triggered by the shortening of the nucleus vowel. When the nucleus is shortened, the tone and the sonorant have to be reassociated. The number of underlying unit tones the V can be associated with is determined by the number of sonorants it links. After one vowel is deleted from the nucleus, only two tones can be associated. By the Association Convention, it is the first two tones that are associated. 4 has to be deleted since it is not associated. (21).

a).
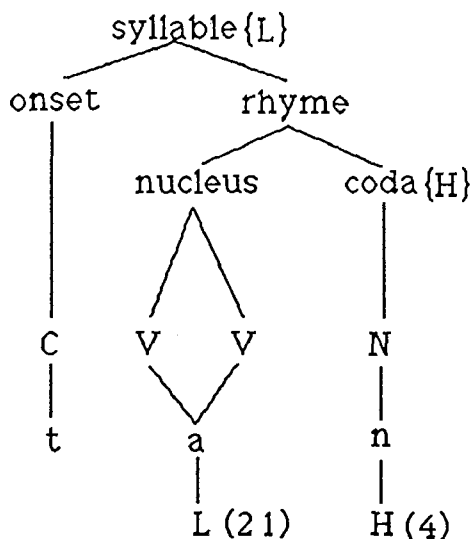
b).
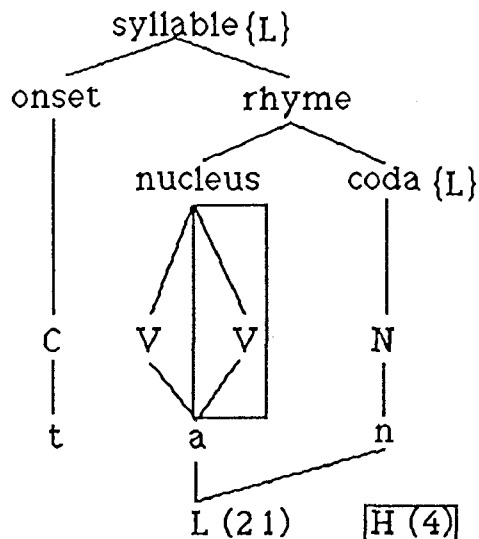
In syllables containing the nucleus vowel only, the process is shown as the following:

(22).

a).
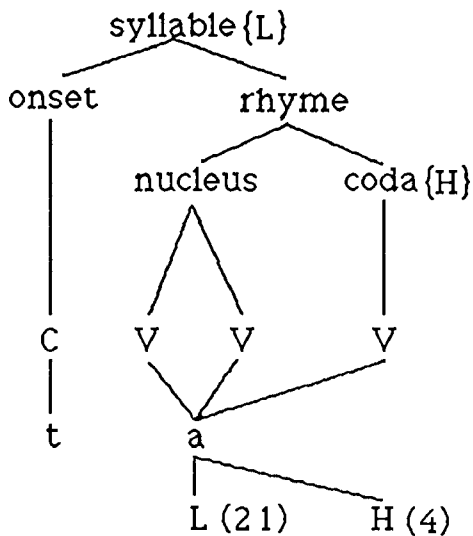
b).
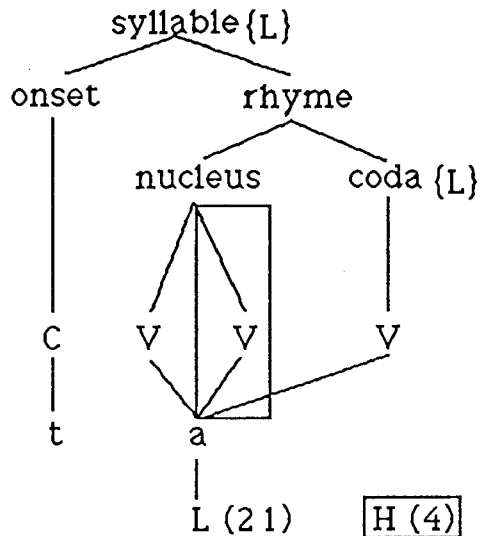
In both cases, the branching nucleus indicates the length. The more branches the nucleus has the longer the duration. After the nucleus vowel is shortened, the reassociation of the sonorant and the tones applies. Before the vowel is shortened, the coda licenses an H tone as the H tone is associated with the coda sonorant. After the shortening of the vowel, the L tone is reassociated with the coda which by now will license a L tone. The unassociated H tone cannot be licensed, therefore, cannot be realized phonetically.

To sum up, syllables in Chinese dialects may contain three underlying tones at the lexical level. All three of them are licensed, two by the syllable node and one by the coda. In speech, when the syllable is shortened, the tone and the sonorant have to be reassociated. Though this will not affect the licensing in the

syllable, it will affect the coda licensing.

1.3. Register and licensing

Historically, there were four tonal categories in Chinese. Each was further divided into two registers depending on the voice feature of the onset. If the onset was voiced, the syllable started low in pitch, carrying a low register. If the onset was voiceless, the syllable started high in pitch, carrying a high register.

Though the register difference is triggered by the segmental feature at the segmental tier, it is neither a segmental feature, nor a tonal feature. It has to be otherwise specified. For example, Cantonese has nine tones in four tonal categories and two registers. There are no voiced obstruent initials preserved, but the register difference resulting from the voice distinction in the history is maintained even after the devoicing of the onset obstruent.

(23).

	Tone I	Tone II	Tone III	Tone IV
H register	55	35	33	5
				3
L register	11	13	22	2

The Tone IV category is preserved from Middle Chinese. As this category is still marked with a voiceless stop coda, there is no coda licensing, so it is not a tonal category. Of the three pitch heights, 5

is in the high register syllables, 2 in the low register syllable, and 3 is in

between. Only in Cantonese can one find three-way divisions. Actually, the situation is more complex than this. The digits in the figure represent the pitch pattern. Tone I--III have a sonorant coda while Tone IV has a voiceless stop in the coda. The first three tones have either a level tonal pattern or a rising tonal pattern. Tone IV only has a pitch height that was determined by certain features of the onset. There are four level tones at the lexical level. With only the tonal features H and L discussed earlier, it is not possible to represent all of the four lexical level tones. In this situation, the register feature should be included in the representation. Syllables can appear in either one of the registers, which is shown below:

(24).

Tone I	H 55	[pa] 'cling to'	[pɪŋ] 'whip'
	L 11	[p'a] 'crawl'	[p'ɪŋ] 'cheep'
Tone III	H 33	[pa] 'tyrant'	[pɪŋ] 'change'
	L 22	[pa] 'stop'	[pɪŋ] 'distinguish'

Except for the aspiration in the L register of Tone I, the syllables in all the rest are identical. In order to solve the representation problem, registers will be used as features as well, which is either HR or LR. In the licensing theory, the segmental features of the onset are all licensed by the syllable node, which also licenses the

tone.   In the licensing domain the tonal feature is determined with reference to the segmental feature licensed.   As the register feature is initiated by the

segmental feature and is licensed by the syllable, it will be represented as {LR} or {HR} together with the tonal feature {L}, {H} by the syllable node.   The four level tones in Cantonese can be represented as:

(25).

Tone I (55)   Tone I (11)

```
        syllable{HR},{H}                    syllable{LR},{L}
        /        \                          /        \
   onset          rhyme                onset          rhyme
     |           /     \                 |           /     \
     |      nucleus    coda{H}           |      nucleus    coda{L}
     |         |         |               |         |         |
     C         V         N               C         V         N
     |         |         |               |         |         |
     p         I         ŋ               p'        I         ŋ
               |_____/                          |_____/
               H                                   L
```

-30-

Tone III (33)

```
        syllable {HR},{L}
         /          \
     onset          rhyme
       |           /     \
       |      nucleus   coda {L}
       |         |         |
       C         V         N
       |         |         |
       P         I         ŋ
                 |_____|
                      L
```

Tone III (22)

```
        syllable {LR}, {H}
         /          \
     onset          rhyme
       |           /     \
       |      nucleus   coda {H}
       |         |         |
       C         V         N
       |         |         |
       P         I         ŋ
                 |_____|
                      H
```
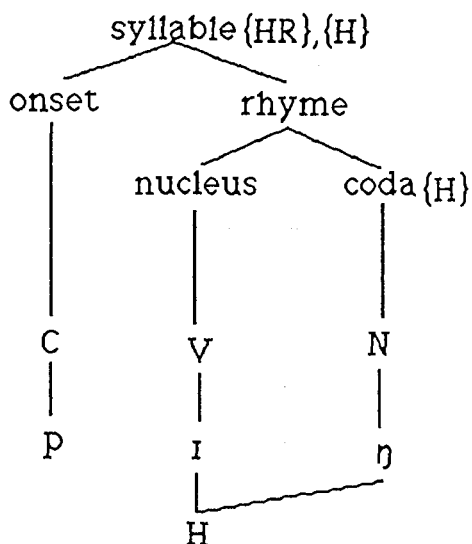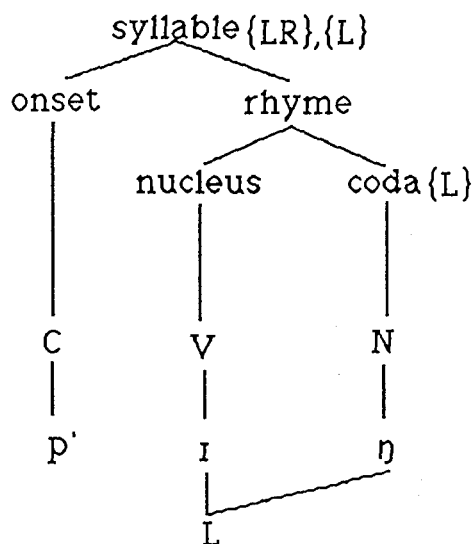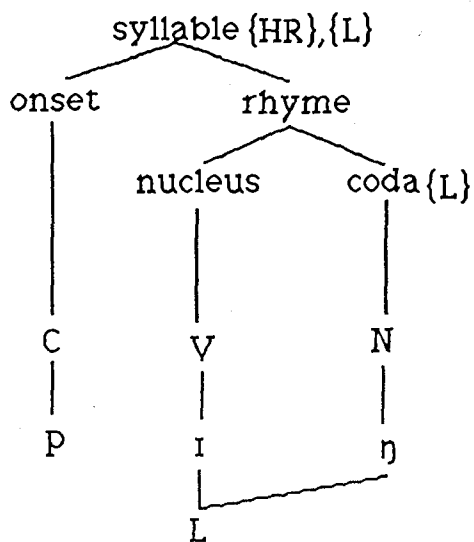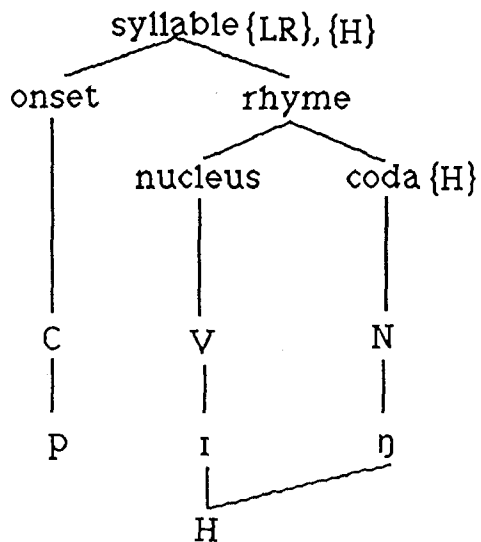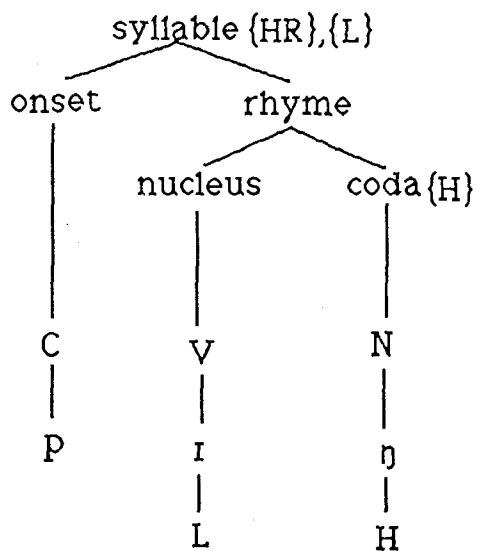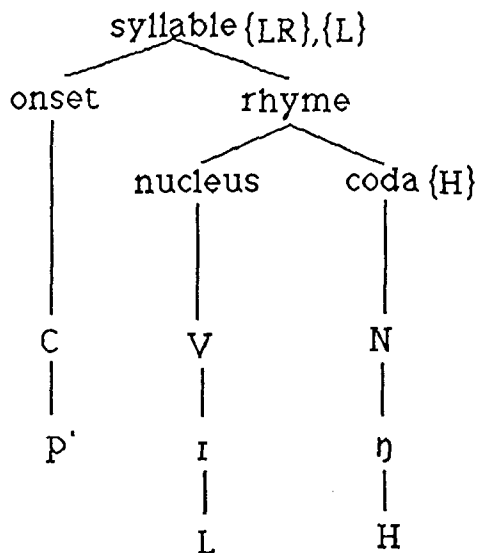
The two rising tones in two registers can be represented the same way.

(26).

Tone II (35)

```
        syllable {HR},{L}
         /          \
     onset          rhyme
       |           /     \
       |      nucleus   coda {H}
       |         |         |
       C         V         N
       |         |         |
       P         I         ŋ
                 |         |
                 L         H
```

Tone II (13)

```
        syllable {LR},{L}
         /          \
     onset          rhyme
       |           /     \
       |      nucleus   coda {H}
       |         |         |
       C         V         N
       |         |         |
       P'        I         ŋ
                 |         |
                 L         H
```

In Wu where voiced feature on the onset is preserved, register is easily identified by this feature. In Cantonese, the register has to be

marked in the lexicon, as no voiced obstruent in the onset exists any more. In another words, the register feature is licensed before the voiced consonant is devoiced. So even after the voice distinction in the onset is lost, the licensed features {LR} and {HR} still function as if they were there. This memory storage is an important feature of licensing.

The above discussion shows that not only the segmental features and tonal features are licensed by the licenser, but also the register feature is licensed in the same way. In Chapter Four, we will see in detail how the feature in the onset can affect tones.

Summary

This chapter has demonstrated how autosegmental licensing operates in Chinese. The notion of tonal domain is combined with the notion of licensing in that segments in a syllable are in the licensing domain of the licenser. Only underlying unit tones associated with sonorants at the segmental tier and licensed by the licensers are realized phonetically. In order to form a phonetic tone, at least two underlying tones need to be licensed by both syllable node and coda node. A syllable in Chinese may have three underlying tones at most, with two associated with the nucleus vowel and licensed by the syllable, and one not only associated with but also licensed by the coda. the register feature is also licensed by the syllable, which determines the register status of the whole syllable.

Notes to Chapter One:

1. The discussion on tonal domain in Chinese can be found in Dow (1972), Howie (1974), Shen et al (1961), Cheng (1966), Chao (1968), Kratochvil (1970), Woo (1969), Wang (1967), etc. Most of their arguments are based on the phonetic perception of elements that can bear a tone phonetically. If a tonal domain only includes those tone-bearing units, the function of the non-tone-bearing units cannot be fully accounted for and also the role of non-tone-bearing units in tonal merger and split and tonogenesis.

2. The 16 syllable types do not exist in all locations. Syllables with a voiceless stop ending belonging to middle Chinese Tone IV category can only be found in most southern dialects like Yue, Min, Xiang, Wu, Kejia, etc. The majority of the northern dialects have lost this category, therefore, they only have syllable types 1-13 in the following list. The sound of the example words is given in phonetic transcription:

Syllable Types	Example	Gloss
1. V	[a]	ah
2. VG	[aj]	love
3. VN	[in]	cloudy
4. GV	[jɛ]	night
5. GVG	[jaw]	to want
6. GVN	[wen]	warm
7. CV	[pa]	eight
8. CVG	[mej]	younger sister
9. CVN	[lan]	blue
10. CGV	[kwa]	melon
11. CGVN	[hwan]	to return
12. CGVG	[hwaj]	bad
13. VC	[ap]	duck
14. GVC	[jɔk]	key
15. CGVC	[tsjɔk]	candle
16. CVC	[lɔk]	to iron

(*Dictionary of Chinese dialects*
(in Chinese) 1959)

3. In order to avoid the controversy whether different forms of

Chinese should be referred to as languages or dialects, variety at different locations will be used in this thesis, e.g. Wu is a variety that has the locations at Shanghai (Shanghainese), Suzhou, Wenzhou, etc.

4.   Duanmu (1990) regards the medial as a secondary articulation of the onset consonant.   He thinks that "what are traditionally written as prenucleus clusters, i.e. [tu-, ti-, du-, di-, nu-, ni-, lu-, li-,...] are in fact single segments, i.e. [t^w-, t^y-, d^w-, d^y-, n^w-, n^y-, l^w-, l^y-, ...] with the glide being a secondary articulation".   For details, see Duanmu (1990:30).

5.   The Roman numerals I, II, III and IV are used to refer to middle Chinese four tonal categories.   They are different from the four tones in Mandarin which are mainly developed from the first three tones of Middle Chinese:

Middle Chinese Tones	Mandarin Tones
Tone I (Level)	Tone 1
	Tone 2
Tone II (Rising)	Tone 3
Tone III (Departing)	Tone 4
Tone IV (Entering)	

6.   By tonal pattern, we refer to the phonetic shape of a lexical tone, e.g. ma (55) is a high level tone, and ma (35) is a rising tone.   We call the level and rising the tonal patterns of the syllable m a respectively.

7.   This system of using digits to represent tones was first used by Chao (1930).   The pitch range is marked 1-5 with 5 as the highest pitch and 1 the lowest one.   Any lexical tone in Chinese can be described using the system.   For example, it can indicate a level tone as 55, 33, or 11, depending on the pitch level; or a contour tone as 35, 14, 52, etc. to indicate both the contour and the pitch range of the starting point and the ending point.   This system is also able to indicate the length by using different number of digits.

Three-digit tone like 214 is longer than a two-digit tone 35, which in turn is longer than a one-digit tone 5.

8. The Association Convention given by Goldsmith (1990:14) is as the following:

> "Association Convention
> When unassociated vowels and tones appear on the same side of an association line, they will be automatically associated in a one-to-one fashion, radiating outward from the association line".

In Chinese, the first association line is always between the nucleus vowel and the leftmost tone. So the remaining tone and sonorant will be associated on a one-to-one basis from left to right.

9. The pitch height of a neutral tone is determined by the tone of its preceding syllable as is shown in the fallowing:

Preceding Tone	Neutral Tone Pitch
Tone 1 (55)	3
Tone 2 (35)	3
Tone 3 (21(4))	4
Tone 4 (51)	1

(Hu 1981:131)

Chapter Two

Development of Chinese

It is believed that all modern Chinese dialects are descended from a common ancestor Chinese which is called Old Chinese or Middle Chinese depending on the time referred to[1], though some say that Min possesses a slightly different history than the rest (Karlgren 1920, 1922; Norman 1988, etc.). First of all, all varieties have monosyllabic morphemes and they all have a uniform syllable structure, as is mentioned above. Secondly, regardless of how many 'tones' a variety has, these tones are all organized into four tonal categories established between 400-500 A.D. In this part we will examine briefly the development of consonants and tone as they are our major concerns.

2.1. Development of consonant system

Though Guo (1986) suggests that Chinese, like Tibetan, was once a "polysyllabic" language and that each syllable had consonant cluster initial and final in Old Chinese, the internal structure of syllables has been quite stable throughout history. The only difference between an Old Chinese syllable and a Modern Mandarin syllable is that there were consonant clusters in the former while no form of Modern Chinese allows any consonant cluster at either syllable initial or final position.

In modern Chinese, the coda is far more restricted in that only

a limited number of consonants are allowed. For example, in Mandarin while almost all of the consonants (except [ŋ]) are allowed to take the onset position, only [-n] and [-ŋ] are allowed in the coda. Taking the coda as a whole, we find that only voiceless stops and nasals can appear in it, if we do not count a postvocalic glide as a consonant. The stop endings include [-p], [-t], [-k], and [-ʔ]. It is believed that in Old Chinese and Middle Chinese there were [-p], [-t] and [-k] endings only. In the course of their development they have merged and decayed, first to a glottal stop and then, in some places, have been lost altogether:

(27).

-p
-t ——→ -t ——→ -k ——→ -ʔ ——→ ∅
-k
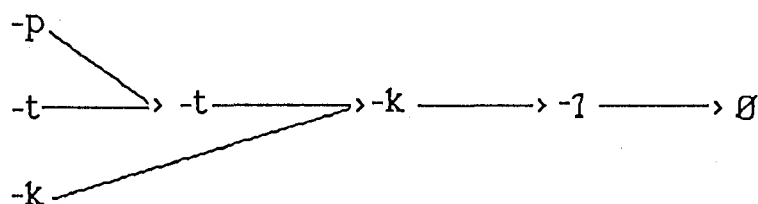
(Chen 1985)

More and more evidence has been found that during the pretonic period of Chinese, the four tonal categories of Old Chinese were distinguished by different consonant endings marking each category. for example, Tone I was marked with a voiced glottal fricative [ɦ]; Tone II was marked with a glottal stop [ʔ]; Tone III was marked by a voiceless fricative [s], and Tone IV was marked by voiceless stops [p], [t], and [k] (Pulleyblank, 1978, Mei, 1970a, etc.)

At the time of tonogenesis, the consonant ending was dropped and the contrast displaced to a tonal pattern that would become

the primary distinctive feature. We have no way of knowing the sources for those original consonant endings. However, at tonogenesis, the less persistent endings like -- [-ɦ], [-ʔ] and [-s] -- disappeared first. The categories marked with these consonants developed into tonal categories first. Compared with these endings, [p], [t], and [k] endings are more persistent in that they are retained much longer. In fact, they are still found today in some southern varieties like Cantonese, Min, etc. Some varieties like Wu have merged them all to a glottal stop, which has started to drop at some Wu locations such as Wenzhou[2]. After the stop ending is dropped completely, the four tonal categories will all be distinguished solely by their tonal features.

The nasal endings are preserved to a varying degree in different places: some have kept all three [-m], [-n], and [-ŋ] as in Cantonese; some two: [-n] and [-ŋ] as in Mandarin, and some have only [-ŋ] left as in Shanghainese.

Syllables with nasal endings are found in Tone I, II and III. It is possible that nasal endings developed together with the tonal development. Obviously, only tonal categories (Tone I-III) have syllables with nasal endings. Tone IV category never develops nasal endings because it never develops its own tonal pattern.

In the onset position, modern forms of Chinese allow one consonant, or at most a consonant plus a glide. By comparison, Tibetan (especially Amdo Tibetan) allows consonant clusters of the types CC-, CCC-, and even CCCC- (e.g. tl-, pt- pkt-, xsdl-, etc.)

(Guo 1986, Yan 1980, Xu 1980, etc.). In the history, for some reason, those clusters were reduced to a single consonant before tonogenesis in Chinese.

The onset consonants are divided into three groups in Old Chinese:

1), voiceless obstruents (both aspirated and unaspirated);

2), voiced obstruents and

3), sonorant consonants

The basis for this division is that they behave differently in interaction with tones. By 1324 A.D. most of the voiced obstruents were devoiced in the north and at some southern locations (L. Wang, 1985). Voiced obstruent onsets are best preserved in Wu (e.g. Shanghainese) and in some Xiang (Hunanese) locations. A direct effect of the voicing contrast is the register division. Usually the high register goes with syllables with voiceless onset and the low register with voiced onset.

After tonogenesis, each tonal category developed two registers because of the voicing distinction. As the devoicing did not happen in all locations, the result is that at modern times, the register status varies from place to place. Briefly, the reflexes of these changes can be grouped into three types:

1) varieties like Mandarin, in which after the devoicing, the pitch differences recombined or the original tone failed to split as Tone 3 and 4 in Mandarin. However, sometimes they developed into two independent tones as Tone 1 and 2 in Mandarin. In this

group, though the register feature is licensed by the syllable node as a licenser, it no longer affects tonal feature assignment.

2) varieties like Wu and Xiang, in which the devoicing has never happened. In this group, the register division is observable in the voice feature of the onset. In Shanghainese, syllables with either [+voice] or [+son] feature in the onset are low register syllables. And syllables with either [-voice] or a zero onset feature are high register syllables.

3) varieties like Cantonese, in which despite devoicing, the two registers have not merged back into one tone, instead, they have remained independent tones in separate registers. In this situation, we assume that the [+voice] feature that used to condition a register feature is licensed by the syllable. After the devoicing, the licensed feature still functions, so that the syllable is assigned a register feature accordingly. But as the segmental feature [+voice] does not exist in the onset any more, the register feature has to be marked in the lexicon.

2.2. Tonal development

The four tonal categories were first mentioned by Shen Yue in the 4th century A.D. It is believed that a tonal contrast or a near tonal contrast among different categories must have existed long before that (Mei 1970a, Wang L. 1985, Pulleyblank 1978,etc). The four tonal categories are given the names as "Level", "Rising", "Departing" and "Entering". For convenience, we will use Tone I -- IV as shown below:

(28).

'Level'	=	Tone I
'Rising'	=	Tone II
'Departing'	=	Tone III
'Entering'	=	Tone IV

The feature [voice] of the onset further divided each tone into a high register and a low register, thus producing eight tones from four tonal categories separated into two registers. After the devoicing of the onset, merging between registers occur within each tone (except for cases such as Shanghainese). In Modern Chinese, we thus find the number of tones to vary from 4 to 9 depending on different degrees of merger. Since this is too complex a process and not our concern, we will leave it here.

In Mandarin (as is found in Beijing), as the stop codas are dropped, Tone IV category no longer exists. Modern Mandarin tones have developed from the first three tones of Middle Chinese with Tone I split up into two tones:

(29).

Middle Chinese Tones		Mandarin Tones
Tone I	High Register	Tone 1
	Low Register	Tone 2
Tone II		Tone 3
Tone III		Tone 4
Tone IV		Tone 2 (with voiced onset) Tone 3 (with voiceless onset) Tone 4 (with sonorant onset)

(Wang L. 1985)

This represents a common process of development in most northern forms of Chinese. In some southern varieties like Yue and Wu, the four tonal categories of Middle Chinese are fully preserved.

There is much controversy in the literature as to the source of the four tones in Middle Chinese. Some hold that tone was an intrinsic property of the language, which did not develop from non-tonal features (Dong 1959). Some maintain that tonal contrasts developed from vowel length contrast (L. Wang 1985). Others suggest that they developed from the loss of a syllable final consonant. Mei (1970a), Pulleyblank (1978), Karlgren (1954), W. S-Y, Wang (1967) etc. take this last view, which is the prevailing view in Chinese linguistics now. We agree with their assumption and will use Mei and Pulleyblank's account to be the

basis of the argument that the four tones of Middle Chinese correspond to different consonant endings of Old Chinese. For more detail, see Mei (1970a), Pulleyblank (1965,1978), etc.

(30).

Consonant Endings in Old Chinese	Tones in Middle Chinese
[-ɦ]	Tone I (Level)
[-ʔ]	Tone II (Rising)
[-s]	Tone III (Departing)
[-p], [-t], [-k]	Tone IV (Entering)

The loss of the consonant ending in the first three tones triggered the formation of a tonal distinction. The different consonant endings had affected the pitch pattern of the syllable both in pitch height and duration. After they had dropped, the pitch pattern of the syllable was preserved, which became the distinctive feature. Hence, Chinese has developed from a non-tone language to a tone language, where a previous redundant pitch feature becomes a lexically marked distinctive feature.

The evidence Mei and Pulleyblank give for such a hypothesis comes from different sources: 1) some modern Chinese coastal dialects, 2) some Buddhist writing around 800 A.D. and 3) some genetically unrelated languages like Vietnamese for which there is more evidence for a final consonant as the source of tone. We will

not explore this evidence here, but will take the hypothesis to be well-supported.

2.3. Development of tonal patterns

It is almost an impossible task for anyone to determine the tonal pattern of Chinese at different stages of development. The names given to the Middle Chinese tone "Level","Rising" "Departing" and "Entering" are very vague. They are often interpreted differently by different people. For example, in determining the tonal pattern of the "departing" tone (Tone III), Karlgren (1960) thinks that it was a falling tone, because this tone is falling in Mandarin now. He has obviously been influenced by this fact (Yu 1985). L. Wang (1985) thinks that it probably was a long, mid low rising tone like the 13 tone in Chengdu of Sichuan Province; while Mei (1970a) thinks that it probably was a long, high rising tone. In modern varieties of Chinese, this tone is falling in Mandarin, Jinan, Suzhou, Wenzhou, etc; rising in Xi'an, Hankou, Yangzhou, etc; and level in Changsha, Nanchang, Cantonese, Xiamen, etc.

Chen (1985) has made a study of Chinese dialectology and has reconstructed the following patterns for Chinese tones before 900 A.D.

(31).

	Tone I	Tone II	Tone III	Tone IV
High Register	44	45	322	44
Low Register	33	23	211	22

Chen makes an assumption similar to Karlgren that Tone III is falling, which we will argue later, cannot be the case. Besides, Chen also assumes that the low register and the high register share exactly the same tonal pattern, differing only in pitch height, which we believe is not the case, either. We will discuss these matters in detail in later chapters.

Consider first the Tone IV category. Since it still has a voiceless stop ending in the coda, the syllable is short and toneless. It cannot have a tonal pattern 44, which is the same as that of Tone I. It should be represented by 4 in the H register and 2 in the L register, as the number of digits used should be able to tell the length difference as well[3].

Secondly, let us examine the claims of Mei (1970a). He has summed up the tonal pattern of Middle Chinese around the 8th century A.D. by saying that 1) the Level tone is "long, level, and low"; 2) the Rising tone is "short, level and high"; 3) the Departing tone is "longishness about to be lost and probably high in pitch and rising in contour"; and 4) the Entering tone is "short, with uncertain pitch and contour" .

Mei's assumption is more acceptable than Chen's account in that (1) the Entering tone cannot have any tonal pattern yet because of the existing stop ending. As is shown in Chapter One, when a syllable has a stop ending, it only has the underlying tone in the syllable licensing domain realized phonetically, with the coda still occupied by a non-sonorant. So the syllable cannot bear a tone phonetically, instead, it only bears a pitch realized over the nucleus vowel. The pitch of the syllable is determined by the voice feature of the onset. As a result of licensing and passing of features, the tone associated with the nucleus is licensed by the syllable and assigned a register feature accordingly. In this way, the status of register is determined.

(2) as we will posit later that one of the conditions for tonal merger to occur is for the merged tones to share a similar (if not identical) tonal pattern. It is not likely that a rising tone will merge with a falling tone, for example, without going through an intermediate step in which the two patterns develop toward each other. The evidence from Shanghainese tonal merger can demonstrate this. In Chao's study of Wu, Shanghainese had seven tones in the four tonal categories and two registers in the 1920's as is given by Chao below:

(32).

	Tone I (Level)	Tone II (Rising)	Tone III (Departing)	Tone IV (Entering)
High Register	41	32	23	4
Low Register	13		13	23

(Chao, 1928)

Since then, the seven tones have undergone some merger. In Jin's recent study of Shanghainese (Jin 1986), there are only five tones left, with Tone I low register merged with Tone III low register, and Tone II high register merged with Tone III high register, either because the merged tones share the same tonal pattern (13), or similar patterns (32 and 23).
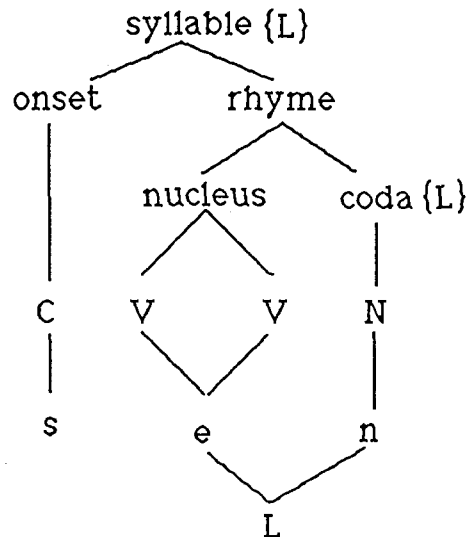
Besides, there is evidence showing that Tone III was once a rising tone. L. Wang (1985) describes the tone as having a rising contour, similar to a 13 pattern. Mei (1970a) gives the tonal pattern of the tone at 800 A.D. to be somewhat long, and high in pitch and rising in contour. Later the rising Tone III undergoes stepwise mutation from place to place becoming a level tone first then a falling tone.

The following will demonstrate how tones in the Middle Chinese are represented in a licensing account.

Tone I is long, low and level. The length is shown by a branching nucleus. The syllable node will license two underlying tones with a multi-association with the nucleus vowels. The coda

will also license a tone. The three associated and licensed underlying unit tones will form a lexical long, level tone, as shown below:
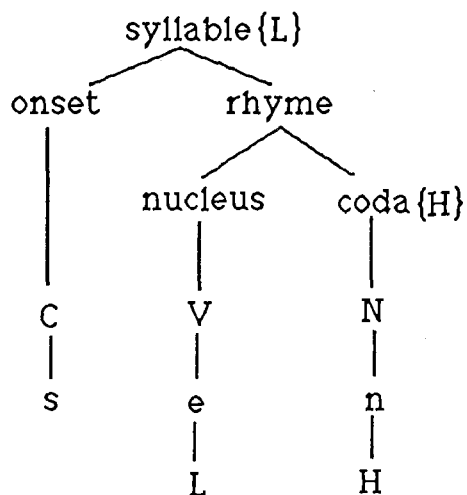
(33).

```
                    syllable {L}
                   /          \
            onset              rhyme
              |               /      \
              |          nucleus      coda {L}
              |          /     \        |
              C        V         V      N
              |         \       /       |
              s           \   /         |
                            e           n
                            \         /
                              \     /
                                L
```

where the L is associated with three sonorants. Both the syllable and coda license L tones. The L will be interpreted as a long, level, low tone phonetically.

Both Tone II and Tone III are rising with Tone III longer than Tone II. Tone II can be represented as:
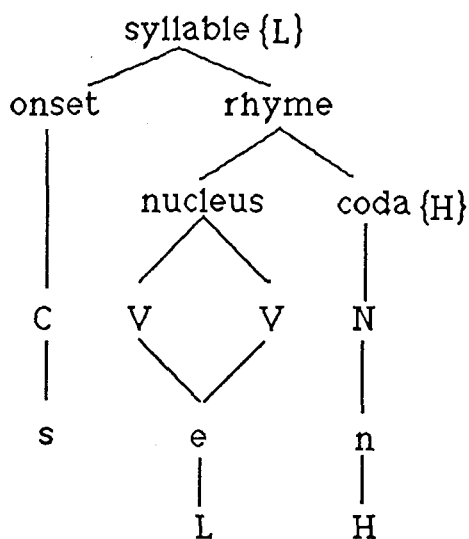
(34).

```
                    syllable{L}
                  /            \
            onset              rhyme
              |              /       \
              |        nucleus      coda{H}
              |           |            |
              C           V            N
              |           |            |
              s           e            n
                          |            |
                          L            H
```

where the L is associated with V and licensed by the syllable. The
H is associated with and licensed by the coda. Phonetically, the LH
sequence will be interpreted as a short rising tone as there is no
branching in the nucleus.

As Tone III is longer than Tone II, the length is shown by the
branching nucleus:

(35).

```
                    syllable {L}
                  /            \
            onset              rhyme
              |              /       \
              |        nucleus      coda {H}
              |         /     \         |
              C        V       V        N
              |         \     /         |
              s          \   /          |
                          e             n
                          |             |
                          L             H
```

As the L is associated with two sonorants in the nucleus, it is long. The LH with a multi-associated L will be interpreted as a long, rising tone phonetically. This will be discussed in detail in the next chapter.

2.4. Major tonal changes

There are three major changes in the tonal development of Chinese: 1) merger of Low register of Tone II into Tone III, which occured around 8th century A.D.; 2) Tone I split based on the voice feature of the initial consonant, which was completed in most of the northern Chinese including Mandarin before 1324 A.D.; and 3) Tone IV syllables merging into other three tones after they have lost the stop ending, which also occured in the majority of northern forms before 1324 A.D.

In all of the above mentioned changes, consonants have played a major role in determining the manner and the direction of the change, in addition to tonogenesis, which also involves the interaction between consonants and tones. In fact, the interaction between consonants and tones in Chinese forms the basis of tonal development.

Summary

Assuming Chinese once was much more consonant-rich than today, it has undergone dramatic development. It has evolved from a non-tone language to a tone language. Consonants have

simplified from consonant clusters to a single consonant at both the onset and coda positions. Tonal features have become major distinctive features after the syllable has dropped its obstruent ending in different tonal categories. The tonal patterns of Tone I, II and III at about 800 A.D. are described as: Tone I being long, low and level, represented by a multi-associated and licensed L; Tone II being rising and short, represented as LH; and Tone III being long and rising, also represented as LH with a multi-associated and licensed L that indicates the length.

Notes to Chapter Two

1. The time division in this thesis is a little different from the tradition. The pretonic period is referred to as Old Chinese; Middle Chinese refers to the period between 800 A.D. and 1324 A.D.; and Modern Chinese refers to the time after 1324 A.D..

2. The Tone IV category in Wenzhou was marked by a voiceless stop. In *dictionary of Chinese dialects* (in Chinese) (1959), this category has lost the stop ending. The acquired tonal pattern of the two tones are 23 in the high register and 12 in the low register respectively.

3. In Cantonese, Tone IV syllables have a̲ and a̲: contrast in length. In this case, a long Tone IV syllable [a:p] is still considered to be shorter than a syllable [a] in other tonal categories phonologically.

Chapter Three

Tonogenesis

Tonogenesis is a process when a primary segmental distinctive feature is replaced by a tonal distinctive feature as a result of certain segmental changes. It is assumed that the four tonal categories of Middle Chinese developed from the four categories in Old Chinese that ended in different consonants, with Tone I in voiced glottal fricative [-ɦ], Tone II in glottal stop [-ʔ] and Tone III in voiceless fricative [-s] which later became a voiceless glottal fricative [-h] before it dropped. The dropping of those consonant endings at tonogenesis induced the establishment of tonal features to be built up as primary distinctive features.

In this chapter, some phonetic evidence will be examined first to see what impact a postvocalic consonant has on the pitch pattern of the whole syllable. Then the source for nasal endings will be discussed. Finally, the phenomenon will be interpreted in the autosegmental licensing discussed earlier.

3.1. Historical data and assumptions

If we take the most prevailing view that tonogenesis involved the losing of syllable final consonant (Mei,1970a; Pulleyblank, 1978; Wang, 1987; etc.), it has to be determined what features in those consonants may have caused a pitch pattern distinction. In the previous chapter it is shown that the tonal pattern at around

8th century A.D. as posited by Mei (1970a) are: Tone I (Level) was low, long and level, and both Tone II (Rising) and Tone III (Departing) high and rising with contrast in length with Tone III longer than Tone II.

(36).

Tone	Description	Consonant Ending
Tone I	low, level, long	[-ɦ]
Tone II	high, rising, short	[-ʔ]
Tone III	high, rising, long	[-s]

Since the two features [±voice] and [±cont] are sufficient to make the three consonant endings distinct, they will be examined if they are sufficient to induce contrasts of the pitch. Tonogenesis is a complicated process that involves both onset and coda segments. In autosegmental licensing, the syllable node does not license any feature carried by the coda. In this sense, any feature from the coda should not affect the tone associated with the nucleus vowel, which only responds to features licensed in the syllable licensing domain. As all of the consonant endings listed above appear in the coda, we will first look at the tone licensed by the coda in this part.

For the consonant endings, they differ in two ways: voicing (voiced versus voiceless) and manner (stop versus fricative). The endings for Tone I is [-ɦ] in Mei (1970a) and Pulleyblank's (1963)

analysis. Both tone II and III end in voiceless consonants. If the syllables in the three tones are otherwise the same, only contrasting in this final consonant, then it is plausible to suggest that this contrast in voicing causes the pitch height to contrast, with Tone I (voiced) low and Tone II and III (voiceless) high.

On the other hand, the length of the syllable-final consonant seems to be able to determine the length of the syllable as well, for syllables ending in [-s] ([+cont]) are longer than syllables ending in a stop [-ʔ]([-cont]). L. Wang (1985), Mei (1970a) argue that Tone I is the longest of all tones. Though Tone III is longer than Tone II, it is not as long as Tone I.

Using two features [±voice] and [±cont], the first three tones can be distinguished (as Tone IV still keeps its voiceless stop ending and no tonal pattern is formed out of it yet):
(37).

Consonant Ending	[voice]	[cont]
[-ɦ] (Tone I)	+	+
[-ʔ] (Tone II)	—	—
[-s] (Tone III)	—	+

From this state-of-affairs, I assume that for syllable with a voiced consonant ending, if the consonant ending is dropped upon tonogenesis, a long low level tone results; and a high, rising tone is produced if the consonant ending is voiceless. In addition, if the

consonant has the feature continuant, the tone is long, otherwise it is short.

3.2. Phonetic evidence

First, let us look at the phonetic evidence for the effect of a following consonant on syllable length.

Lehiste (1970) has made a study on the contribution of postvocalic consonants to the duration of a preceding vowel, and found that many factors--including the voice feature and the manner feature--may affect the duration of the preceding vowel[1], though the result can be language dependent. In English, for example, as is given by House and Fairbanks (1953) "vowels are shortest before voiceless stops, and their duration increases, in this order, when the postvocalic consonants belong to the classes of voiceless fricatives, nasals, voiced stops, and voiced fricatives" (Lehiste 1970:24). Though the study was conducted on English, yet "there has been a slight tendency to assume that what holds for English is true in general" (Lehiste 1970:19). The above relationship between postvocalic consonant and the duration of the preceding vowel is summed up as the following: (38).

				length of vowel	
shortest				longest	
Final C	voiceless stops	voiceless fricatives	nasals	voiced stops	voiced fricatives
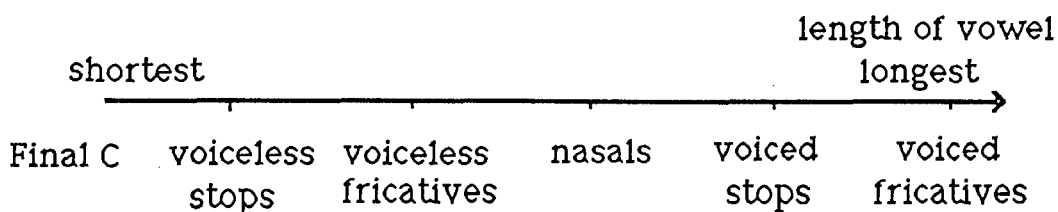
This result is obtained from either tested pairs of words like heat-heed; back-bag-bang, etc, which do not have a vowel length contrast, or nonsense words. In Chinese, the duration of the nucleus vowel seems to be affected by the following consonant in the same order. It is largely determined by both voice and manner features of the following consonant ending.

However, the same result cannot be obtained from all languages. Elert (1964) found that in Swedish vowels before -t were shorter than vowels before -s, but vowels before -t are a little longer than vowels before -n and vowels before -s are much longer than vowels before -n.

In Spanish, a vowel is shortest before a voiceless plosive and it becomes longer in the order of voiceless fricatives, voiced fricatives and liquid (Navarro Tomás, 1916).

Nevertheless, the sounds in question here always rank in the order: voiceless stops < voiceless fricatives < voiced fricatives, in inducing length difference in the preceding vowel.

While the relationship between the syllable final consonant and the duration of the preceding vowel can be established, a relationship between the consonant and the pitch pattern of the preceding vowel cannot be established directly from any consistent acoustic facts. This second relationship is not only that between final consonant and pitch height, as Tone I is low and both Tone II and III are high, it also has to do with a pitch

pattern to be formed which later is converted into a tonal pattern. In the case of Chinese, only two possible tonal patterns are related with the final consonant: level tone versus rising tone. In the case of a voiced fricative ending a level tone is triggered, and in the case of a voiceless consonant, a rising tone is triggered.

But this fact in Chinese is not well supported by data from other languages. Hombert (1978) writes that "tonal development from the loss of a voicing distinction in the postvocalic position is extremely rare (if it exists at all).

Both Mohr (1968) and Slis (1966) "indicate that postvocalic consonants have an effect on F_0 similar to that of prevocalic consonants (i.e. voiced consonant lowering versus voiceless consonants raising the F_0 of the vowel) but with a much smaller magnitude" (Hombert p.92).

Hanson (1975), Lea (1972, 1973) both suggest that both voiced and voiceless consonants lower the F_0 of the preceding vowel.

Still other studies show that voicing may not be the only factor influencing the pitch pattern of the preceding vowel. Of the voiceless group, a voiceless glottal stop triggering a rising tone and a voiceless glottal fricative a falling tone can be found in Vietnamese, the Lolo-Burmese family and Arabic (Haudricourt 1954, Matisoff 1970, 1973, Maran 1971, Mei 1970a, Hombert 1978, etc.). "Thus, if the intrinsic perturbations caused by postvocalic voiced and voiceless consonants on F_0 of preceding vowels are so similar, it is not surprising that they cannot be

reinterpreted as tonal contrasts by speakers"(Hombert, Ohala & Evan 1979). But if we combine the pitch pattern with the length of a syllable, the relationship between the final consonant and the pitch pattern may be sketched indirectly[2]. An underlying tone curve is shown as the following as is described by Hombert, Ohala and Evan (1974:49):

(39).
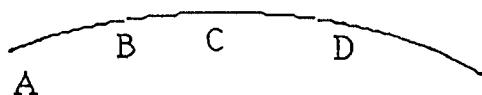
where the pitch pattern will be determined by where the truncation is made according to the length of the syllable. If the truncation happens at an early stage, the pattern will be slightly rising. If the truncation is made at a later stage, the pattern will be slightly rising at the beginning, level in the middle and slightly falling toward the end. So if this contour line is truncated according to the length contrast as a manifestation of the voicing contrast in the final consonant, Tone II will take from A to B, Tone III possibly from A to C, and Tone I from A to D. Here AB and AC can be either level or a slightly rising while AD certainly gives a falling contour. This is different from what we have assumed before. However, the phonetic perception may not be that significant since the patterns of different tones can easily be made distinct already.

In the 17 modern varieties of Chinese we have looked at (shown in (40)), the high register of Tone I can either be a level

tone or a falling tone.   For the low register the situation is different, which we will deal with later.   This shows that the choice between a level tone or a falling tone for Tone I depends on individual development in different forms of Chinese.   Both choices are possible according to the truncated curve AD in (39).
(40).

Locations	Tone I (H)	Features
Beijing	55	HH
Jinan	213	LLH/LLL
Xi'an	21	LL
Taiyuan	11	LL
Hankou	55	HH
Chengdu	44	HH
Yangzhou	31	HL
Suzhou	44	HH
Wenzhou	44	HH
Changsha	33	HH/LL
Shuangfeng	55	HH
Nanchang	42	HL
Meixian	44	HH
Guangzhou	55	HH
Xiamen	55	HH
Chaozhou	33	HH/LL
Fuzhou	44	HH

3.3. Postvocalic nasals

In discussing tonogenesis, there is one aspect of the problem that cannot be ignored, namely the postvocalic nasals. What is their source?   What role do they play in tonogenesis?

In modern Chinese, every variety of the language has nasals at the syllable ending position, one ([-ŋ] in Jinan, two ([-n] and [-ŋ])

in Mandarin, and three ([-m], [-n], [-ŋ]) in Cantonese, for example. As far as their distribution is concerned, they appear in Tone I, Tone II and Tone III. In modern Chinese, postvocalic nasals do not have any influence on tonal distribution. Historical evidence does not demonstrate that they might affect tones, either. In the following we will look at different arguments about nasals, but nothing conclusive can be drawn from them yet.

3.3.1. Nasal endings from Tone I

As to the source of nasal ending syllables, one point of view (L. Wang 1985, Yu 1985) is that they originally came from Tone I, the only category that had syllables ending in a nasal in Old Chinese. L. Wang has reconstructed two types of consonant endings. According to him, in Old Chinese there were nasal endings [-m], [-n], [-ŋ] and stop endings [-p], [-t], [-k] (Tang 1959). Nasal endings existed in level tone only, and stop endings were found in both Tone III and Tone IV (L. Wang 1985).

Though Yu (1985) has reconstructed different endings for the four categories from L. Wang. He also thinks that syllables with nasal endings originated from Tone I category[3].

3.3.2. Nasals from nasalized vowel

Guo (1986) gives a brief description of what Old Chinese before tonogenesis would have been like. He thinks that there were no nasal endings in the pretonic language period, instead, there were

nasalized vowels which at a later stage developed into nasal endings.

Nasalized vowels can be found in many modern locations. In the 17 points we have looked, 8 of them have nasalized vowels as shown below:

(41).

Locations	Nasal Endings	Nasalized Vowels
Xiamen	[-m], [-n], [-ŋ]	
Shuangfeng Changsha Yangzhou	[-n], [-ŋ]	Ṽ
Chaozhou Jinan Xi'an Taiyuan	[-ŋ]	

The rest varieties have nasal endings without nasalized vowels.

One possibility is that the nasalized vowels develop into nasals at different times, that is why in some places we have all three nasal endings, in some others we have only one nasal ending. Another possibility is the opposite: that nasals developed into nasalized vowels. This can be easily explained since all forms of Chinese have nasal endings while only some have nasalized vowels.

In a study of nasalization in Chinese northwest forms, Dow (1974) writes that "as evidence shows, this evidence can be traced back to as early as the middle of the 7th century A.D. In another word, nasalization which is derived from finals ending in /-n/ and

/-ŋ/ is a traditional phonetic characteristic in northwest dialects". This tells us two things: 1). the nasalized vowels developed from nasal endings; and 2). the nasalization happened at the middle of the 7th century which is about the time of tonogenesis.

At around 200 A.D. there were nasal endings already (Tang 1959, Wang L. 1985). the problem is why both nasal endings and nasalized vowels only appear in the first three tonal categories that have developed lexical tones? Tone IV category while still keeping its voiceless stop ending never develops nasal endings nor nasalized vowels. Actually, this may indicate that nasal endings are related to tonal development. Nasal endings could have been part of the syllable from the beginning. But it is hard to explain why they are not fairly distributed in all four tonal categories. They only developed in the categories that had the potentiality of becoming a tonal category. As for Tone IV, since it did not take part in tonogenesis, no nasal ending developed. We assume that the nasal ending is part of the coda before tonogenesis. At tonogenesis, the nasal ending did not affect the way a tone is formed as an obstruent did.

3.3.3. Nasals as part of the coda

The nasal endings were part of the coda at around 800 A.D. Nasals in a coda position behave differently from obstruents in this position, which can still be demonstrated by modern forms of Chinese where only stop endings interfere with tonal behaviors.
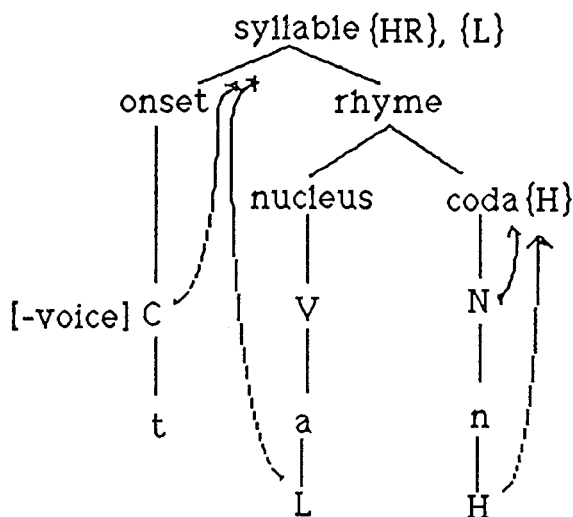
There is no interaction between a nasal ending and the tone. To state it more precisely, in varieties where a stop ending is preserved in Tone IV category, the category does not have a tone developed. It only has a pitch carried by the nucleus vowel: (42).
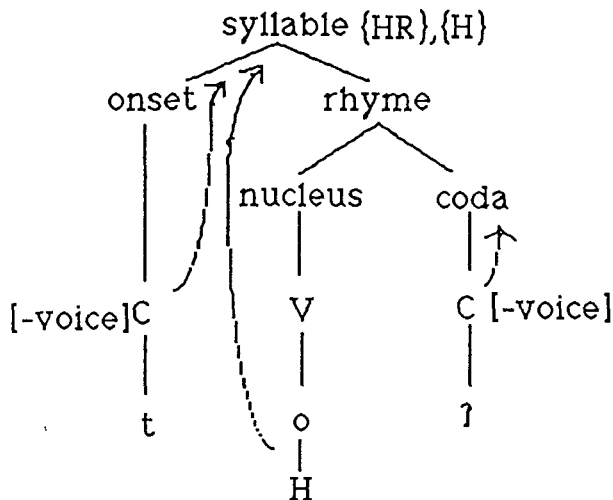
In (42), the syllable licenses both {HR} and {H} features. The coda only licenses segmental features as no tone is associated with the coda. No licensing of tone takes place in the coda. The H tone is interpreted as a pitch because one licensed tone cannot form a lexical tone.

As for the nasal ending, it can carry a tone in the coda's position because it has the feature [+sonorant] and it is assumed that any element that has this feature is able to be associated with a tone.
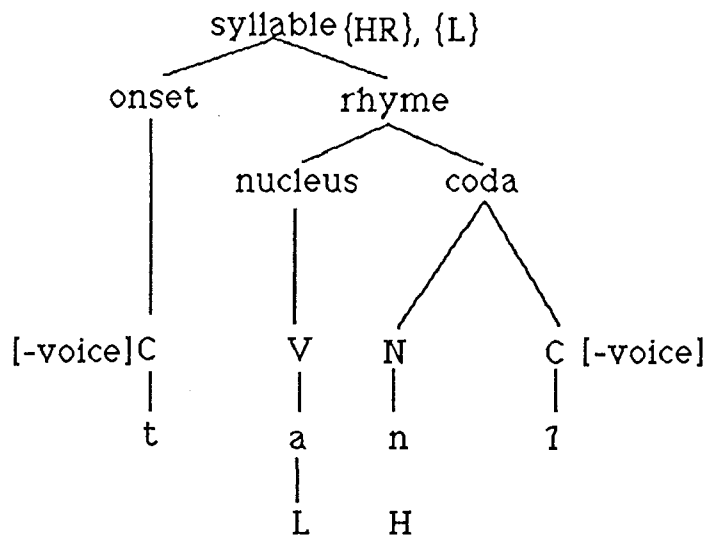
(43).

```
                    syllable {HR}, {L}
                  ╱           ╲
            onset              rhyme
              │              ╱      ╲
              │          nucleus    coda {H}
              │             │          │
   [-voice] C              V          N
              │             │          │
              t             a          n
                            │          │
                            L          H
```

The tone bearing property of different consonant endings is an inherited property from Old Chinese. There was no interaction between nasal endings and tones.

According to Guo (1986) and Yan (1980), before 200 A.D. there might have been obstruent clusters at the coda's position. Later, these clusters were reduced to a single consonant with [-ɦ] in Tone I, [-ʔ] in Tone II and [-s] in Tone III. Before 800 A.D. the nasal endings developed in the first three tonal categories, forming consonant clusters again with the existing obstruents: [-Nɦ] in Tone I, [-Nʔ] in Tone II and [-Ns] in Tone III, where N stands for any nasal ending. The nasal-obstruent cluster is the intermediate stage between non-tone Chinese and tone Chinese. Before the nasals developed, it was not possible for the syllable to carry a pitch pattern even close to the tonal pattern which would be formed after tonogenesis. Such tonogenesis is a reflex of the

previous pitch pattern because the syllable only has one licenser functioning in tone licensing.

In the intermediate stage, when the coda licenses a nasal together with the obstruent, it is possible that the nasal in the coda became associated with an underlying tone as coda licensing source as shown in (44). The problem is that the association between the underlying H tone and the segment in the coda should start from C because C is the head coda and the N is a satellite coda[4]. We suggest a Head Association First Condition, which states that when the coda contains more than one segment, the association with the underlying tone starts with the head coda. But because the C lacks the sonority property needed for the tone association, the C and the H cannot be associated. In addition, because of the existence of the C, the reassociation between the N and the tone is also blocked.
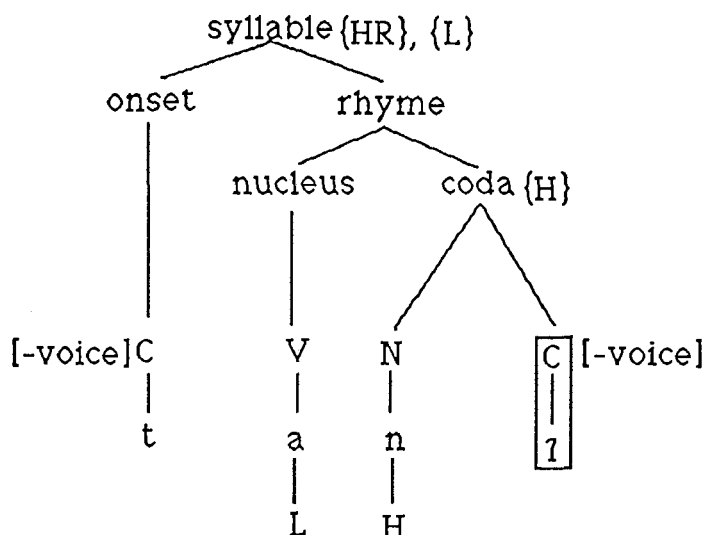
(44).

```
            syllable {HR}, {L}
            ╱         ╲
        onset         rhyme
          │          ╱     ╲
          │      nucleus    coda
          │         │       ╱ ╲
          │         │      ╱   ╲
   [-voice]C        V     N     C [-voice]
          │         │     │     │
          t         a     n     ʔ
                    │
                    L     H
```

At around 800 A.D. the obstruent ending was lost shown in

(45). Now, the reassociation of the N and H can happen. As the features of the lost consonant ending are already licensed by the coda that will also license the tone associated with the nasal, together with the tone licensed by the syllable, LH will be interpreted as a lexical rising tone.

(45).

```
                    syllable {HR}, {L}
                   ╱            ╲
              onset              rhyme
                │              ╱      ╲
                │         nucleus      coda {H}
                │            │         ╱    ╲
                │            │        ╱      ╲
    [-voice] C               V       N      ┌─┐
                │            │       │       │C│ [-voice]
                │            │       │       │ │
                t            a       n       │ │
                             │       │       │ʔ│
                             │       │       └─┘
                             L       H
```

At tonogenesis, the nasal was in the coda, but it did not play any role in it.

There might have been two types of syllables: a syllable with the nucleus vowel and the obstruent ending -VC (Type I); and a syllable with the nucleus vowel and both the nasal and the obstruent ending -VNC (Type II). For Type I, when the final consonant is lost, the tonal pattern will be realized by vowel spreading as discussed before. They become open syllables in Middle Chinese. For Type II, when the obstruent is lost, the syllables will end in a nasal in Middle Chinese. The idea is that

the nasal ending should not affect the tonal pattern, so the syllable with a nasal ending (-VNC) will achieve the same tonal pattern as those without it (-VC).

The following will demonstrate how licensing operates in tonogenesis.

3.4. Representation of tonogenesis

In the representation of tone, the same feature notation is used as in Chapter One. A branching nucleus indicates a long syllable. A multi-associated tone is longer than a non-branching associated tone. The syllable as a licenser only licenses segmental and tonal features in its licensing domain. The coda as a licenser licenses features from both tiers in its licensing domain. The function of the consonant ending is crucial. Its licensed feature will affect the way a tone is formed.

It has been discussed before that in Chinese, the coda is a licenser that licenses a tone only when the coda contains a sonorant that is associated with an underlying tone. That explains why Tone IV does not have a tonal pattern at the phonetic level. This condition of tone association also holds at tonogenesis.

3.4.1. Tonogenesis of Tone I-III (-VC)

The categories involved in tonogenesis are Tone I, II and III. They have obstruent syllable endings, [-ɦ] in Tone I, [-ʔ] in Tone II and [-s] in Tone III. Upon the loss of these endings, a previous

non-distinctive pitch pattern develops into a tonal pattern which can be seen as a reflex of its previous pitch pattern. In addition, after the consonant ending is lost, the syllable is also lengthened by the vowel spreading. After these categories develop individual tonal pattern, Tone I is a long low and level tone; Tone II is a short high rising tone and Tone III is a long high rising tone.
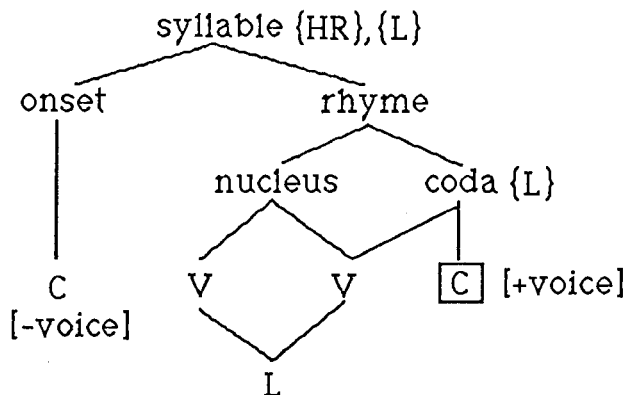
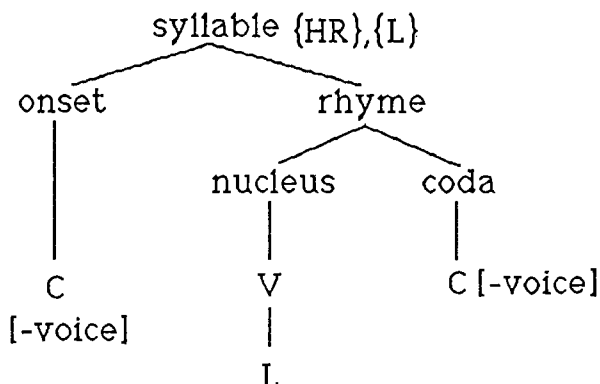Tone I has the following structure before tonogenesis:

(46).
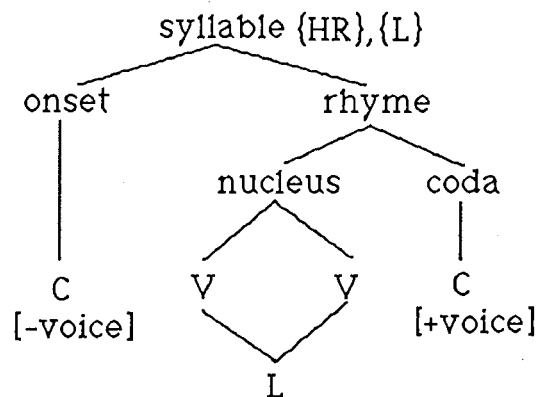
The branching nucleus shows that the syllable is long. The L tone associated with two V's is also long. The tone feature L is licensed by the syllable. As no tone is associated with the coda, no tone is licensed. The syllable at this stage does not have a lexical tone.

(47).

In (47), after the C in the coda is dropped (shown by the box), the coda is reassociated with the nucleus vowel as a result of vowel spreading. The L tone is associated with three sonorants with the L feature licensed by both licensers respectively. So far, the tonogenesis is completed with a new tonal pattern formed at the phonetic level as a primary distinctive feature.

After Tone II and Tone III lose the consonant ending, both categories develop a rising pattern. Tone II is short and Tone III is long. Tone II is represented with a single V in the nucleus: (48).

```
              syllable {HR},{L}
            /              \
        onset              rhyme
          |               /      \
          |          nucleus      coda
          |              |          |
          |              |          |
          C              V        C [-voice]
       [-voice]          |
                         L
```

Before the consonant ending drops, the syllable only carries a pitch realized over the nucleus vowel. The feature [-voice] of the coda C is licensed by the coda. After the C is lost, the syllable becomes lengthened by vowel spreading as is shown in (49). As there is one more sonorant at the segmental tier, the reassociation between the H tone and the coda can happen now. After the tone is associated with the coda, it is licensed by the coda, and assigned a tonal feature with reference to the licensed segmental features.

The LH sequence is phonetically interpreted as a short rising tone, which has become a distinctive feature of the category.

(49).

syllable {HR},{L}

onset   rhyme

           nucleus   coda {H}

C   V   [C] [-voice]

[-voice]   L   H
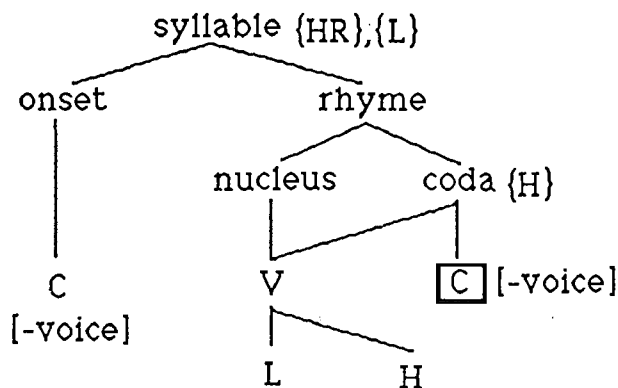
Tone III syllable differs with Tone II in that it has a branching nucleus due to its length. Before tonogenesis, only the L tone associated with the nucleus is licensed. After the C is dropped, the vowel is spread over to the coda that makes it possible for the coda to associate a tone and license the tone. With the feature [-voice] licensed, the tone licensed by it is assigned an H value. The LH sequence with a branching nucleus is interpreted as a long rising tone:

(50).

syllable {HR},{L}

onset   rhyme

           nucleus   coda {H}

C   V   V   [C] [-voice]

[-voice]   L   H
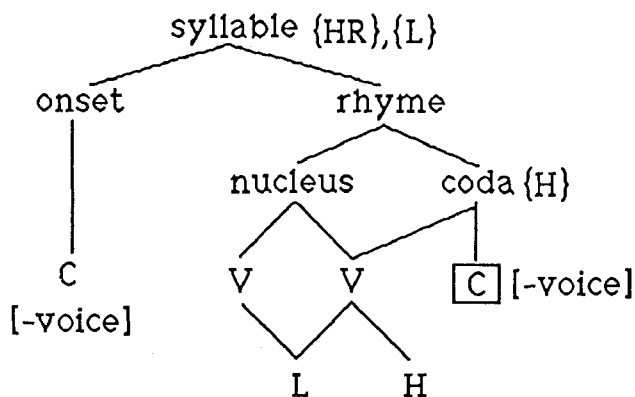
Though both Tone I and III are long, with Tone I even a little longer, the length difference is not significant, for after tonogenesis, the two categories do not contrast in segmental features any more. They contrast in newly formed tonal patterns: level versus rising.

This part has shown the representation of tonogenesis of Middle Chinese open syllables. In the next section, the representation of nasal-obstruent ending syllables is discussed.
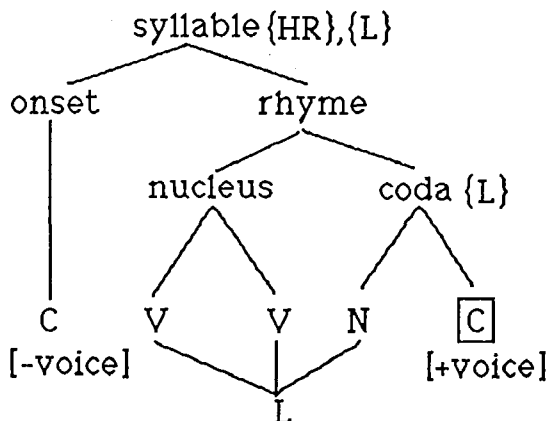

3.4.2. Tonogenesis of Tone I-III (-VNC)

In this type of syllables, it is assumed that at tonogenesis, there are nasal-obstruent endings with the nasals in the coda already. In Tone I, it is shown as:

(51).
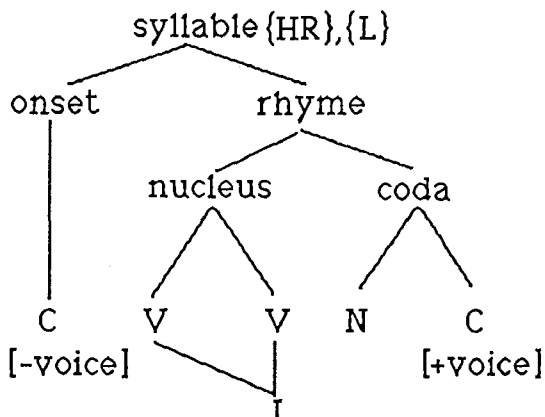
a). b).

In (51) a) both segments in the coda cluster are licensed by the coda. As the nasal is associated in the coda and it is a sonorant, it can be associated with the tone. But the Head Association First Condition has blocked the association. After the obstruent ending

is dropped in (51) b), the nasal and the underlying tone L is reassociated. With the licensed [+voice] feature, the tone also licensed by the coda is assigned an L feature.
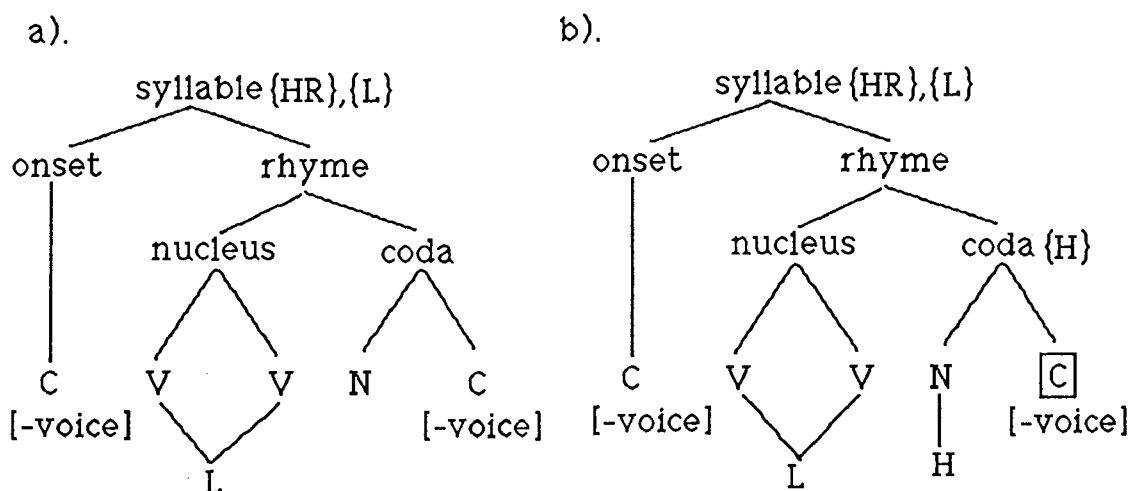
For Tone II, the same derivation can be achieved:

(52).

a).

b).
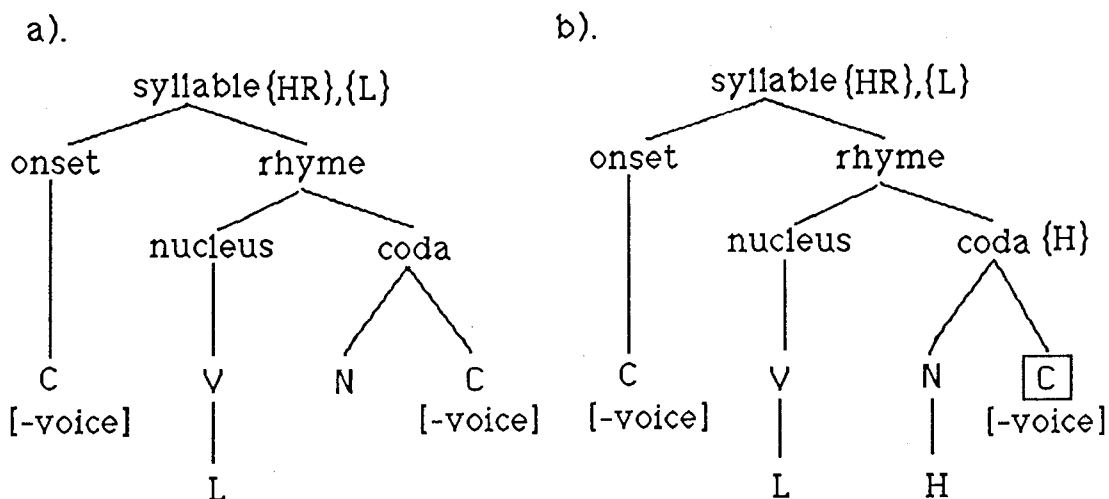
For Tone III, the process is the same.

(53).

a).

b).

For both Tone II and Tone III, as also the case with Tone I, before the consonant endings are dropped, the nasal is not associated with the underlying tone. That is why the nasal did not participate in tonogenesis. After the C ending is dropped, the reassociation applies to link the nasal and the underlying tone. When the tone is associated, it is also licensed and assigned a tonal feature. With sonorants from both licensing domain associated with tones that are licensed by both licensers, a lexical tone is formed. Thus far, tonogenesis has completed in Tone I-III.

3.5. summary

In this chapter, we have discussed tonogenesis, its assumption, the phonetic evidence and its representation. Tonogenesis has happened over a period of time when a syllable carrying a pitch height only develops a tonal pattern by spreading the sonorant (either the vowel spreading over to the coda in open syllables of Middle Chinese, or by developing nasal endings in nasal ending syllables of Middle Chinese). As a matter of fact, the tonal pattern is a reflex of its previous pitch pattern. The length difference is shown by the nucleus vowel. A long syllable has a branching nucleus and a short syllable has a single branch nucleus. Underlying unit tones just licensed by the syllable node can not be realized as a lexical tone. Only when both licensers in the syllable license tones can the licensed tones be realized phonetically forming a lexical tone.

1. The factors that affect the duration of the preceding vowels as given by Lehiste (1970) include "the voicing of a postvocalic sonsonant", "the place of articulation of the consonant", "the extent of the movement of the speech organs required in order to come from the vowel position to the position of the following consonant", "the manner of articulation of a consonant", etc.

2. The following is a citation from Hombert, Ohala and Evan (1979:49):

> It is possible, under certain circumstance, for voiced and voiceless final stops indirectly to affect the tonal contour of the preceding vowel. It is well know that vowels are shorter before voiceless than before voiced consonants (Delattre 1962, M. Chen 1970) thus if a tonal contour appears on a vowel which is followed by a voiceless consonant, it may be 'cut short' and have a different terminal FO than if it appears before a voiced consonant (Y. Erickson and Alstermark 1972, Lofqvist 1975, Bannert and Bredvad-Jensen 1975); see Figure 8. Such an effect has led to detectably different intonation patterns in Jeh (Thomas 1966), but apparently has not yet been reinterpreted in such a way as to produce a lexical tone distinction.

"UNDERLYING' TONAL CONTOUR
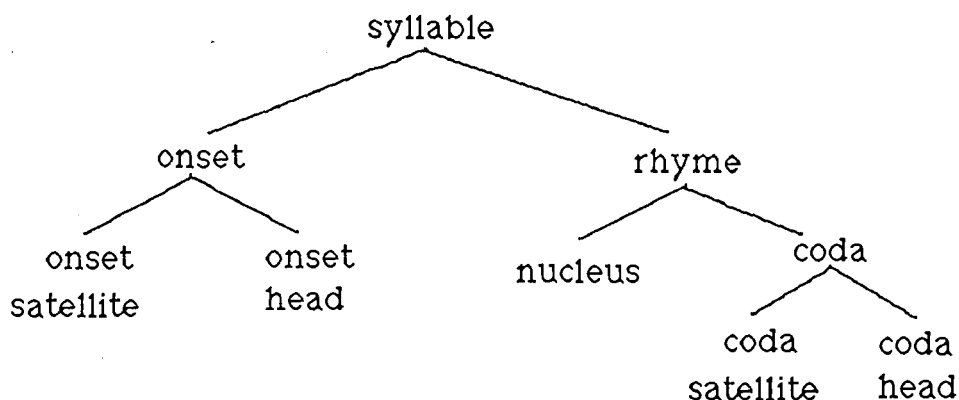
TONAL CONTOUR BEFORE
VOICED CONSONANT

TONAL CONTOUR BEFORE
VOICELESS CONSONANT

Figure 8. Idealized representation of how the same "Underlying" tonal contour (top) could have two different phonetic manifestations before voiced (middle) and voiceless (bottom) final consonants. The effect of the final voiceless consonant (by shortening the vowel) is to truncate the contour, so that the terminal pitch level would be different from that before a final voiced consonant".

3. With Yu's analysis, Tone I in Old Chinese had consonant endings like [-ɦ], [-ɦʷ], [-l], [-r], [-m], [-n], [-ŋ], etc. They are all voiced consonant endings. Tone II adds a glottal stop to the above non-nasal endings and Tone III adds an [-s]. For details, see Yu (1985).

4. The syllable structure given by Fudge (1969) allows either the onset or the coda to branch with a head and one or more satellites:

```
                        syllable
                  /                  \
              onset                    rhyme
             /     \                  /      \
        onset      onset        nucleus       coda
        satellite   head                     /     \
                                          coda      coda
                                          satellite  head
```

Chapter Four.

Interaction between consonants and tone

In this chapter, the interaction between syllable initial consonants and the tone including both tonal split and merger will be examined. In the historical developments leading to Mandarin tonal distributions, three tonal changes occurred under the influence of initial consonants, one being Tone I split, another being the merger of Tone II low register and Tone III low register, and the third being the redistribution of Tone IV syllables after they drop the stop ending (L. Wang, 1985, etc.).

It has been discussed before that the voice feature of the initial consonant has caused register distinction: a high register with voiceless initials and a low register with voiced initials. This register feature is initiated by the voice feature of the onset . It is licensed by the syllable node. Before the voiced initial becomes devoiced, the pitch value of the tone licensed by the syllable is determined by the voice feature of the onset.


4.1. Tone I split

Tone I split occurs when the two registers of Tone I develop into two independent tones after the voice distinction has disappeared. This change has happened to almost all types of Chinese. For example, the Middle Chinese Tone I becomes modern

Mandarin Tone 1 (level) and Tone 2 (rising), while no split has occurred to other tones in Mandarin.

One traditional explanation for Chinese tonal split and merger is that there were four tonal categories in Middle Chinese, because of the voice feature of the initial consonant, each tonal category developed two registers. Around 1324 A.D. a devoicing process occurred in almost all of the northern forms of Chinese and some southern forms. After the voiced initial consonant devoiced, the factor that caused the tonal split into registers no longer existed, so the two registers merged back into one tone. (L. Wang, 1985, etc.). Although this account predicts the development found in northern Mandarin, it fails to explain why in most locations the two registers that developed from Middle Chinese Tone I never merge back into one tone again, instead, they remain distinct and have eventually developed into two independent tones.

According to the tonal system described by Chen (1985), the two registers caused by the voice difference at onset have exactly the same pitch pattern, differing only in pitch height. So Tone I had a high register 44 and a low register 33. This can be illustrated on Chao's pitch range scale:

(54).
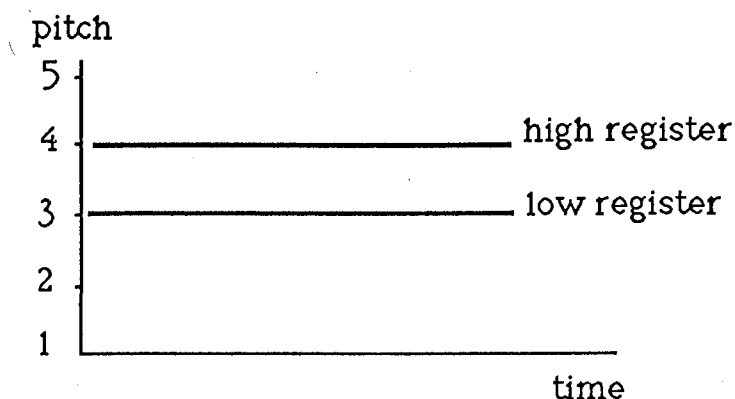
For contour tones, the two registers also have parallel tracks in Chen's assumption. If the high register of a rising tone has a 45 value, the low register would have a 23 value.

(55).
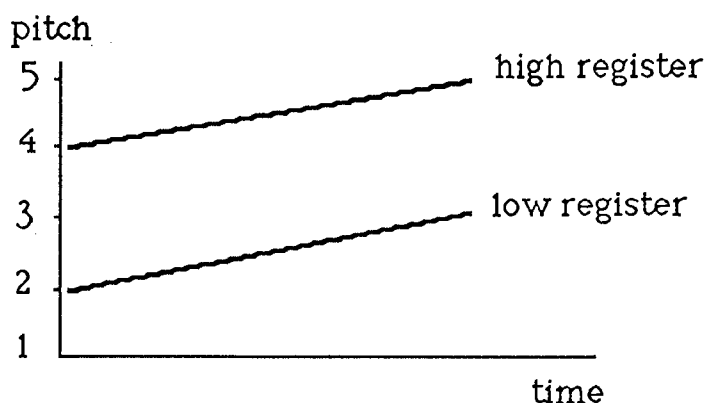
If, as is claimed, the voice feature at onset can affect the pitch pattern of the whole syllable, lowering the low register pitch evenly from that of the high register, we might expect to see a complete merging of the two registers after the onset is devoiced. In the following, we argue that this proposal contradicts the principles outlined here, for the voice feature of the onset causes the register distinction only over the first part of the syllable, i.e.

it cannot have a lowering effect on the whole syllable. This property is well predicted in the autosegmental licensing.

In licensing, the syllable node is a primary licenser that only licenses all the segmental features of the onset and nucleus, as is shown below:

(56).
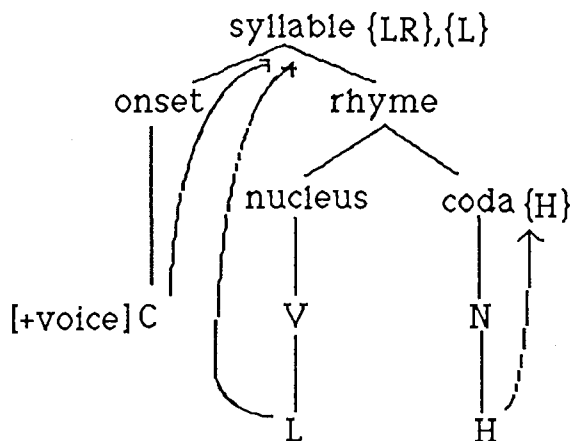
As the coda is also a secondary licenser in Chinese, the segmental features carried by the coda cannot be licensed by the syllable node because they are already licensed by the coda. Therefore, the [+voice] feature licensed by the syllable can only affect the tone assignment to the tone licensed by the syllable. It can never affect the tone licensed by the coda. Supposedly, the two underlying tones were first assigned L feature by the syllable and the coda respectively. When the [+voice] feature licensed by the syllable lower the pitch value of the tone licensed by it, while the tone licensed by the coda, remains unaffected, the unit tone sequence no longer form a level tone. It has acquired a rising pattern representable as LH with the syllable licensing an L tone

and the coda licensing an H tone. Therefore, the two registers no longer differ in pitch height. They are distinctive by different tonal patterns, level versus rising, as is shown below: (57).
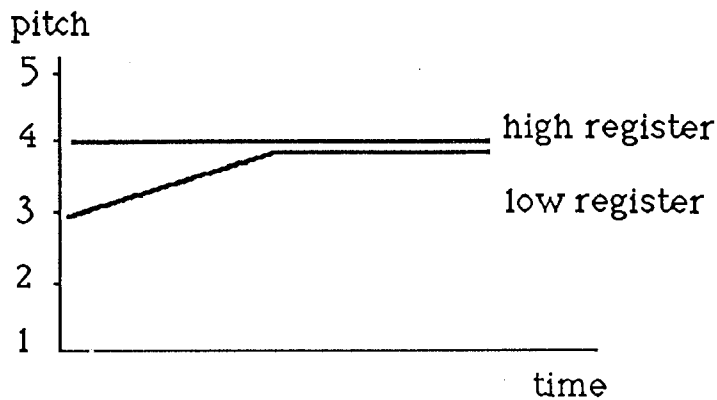
Contemporary Mandarin Tone 1 from Middle Chinese Tone I high register has a 55 pattern and Tone 2 from Middle Chinese Tone I low register has a 35 pattern.

In the following, we will use some phonetic evidence from other languages to show that it works in this way.

4.1.1. Evidence from other languages

It is a commonly observed phenomenon that a voiced initial will lower the F0 of the following vowel. And this effect is regarded as the most common source of tonogenesis. "The development of contrastive tones on vowels due to the loss of a voicing distinction on obstruents in prevocalic position is probably the most well documented type of tonogenesis" (Hombert 1978). And this correlation between initial consonant and tone was

largely noted at the beginning of this century by Maspero (1916) for Vietnamese and by Karlgren (1954) for Chinese, and was later extended to other East and Southeast Asian languages by Haudricourt (1954, 1961), Matisoff (1973), etc. This correlation is also found in other linguistic groups, e.g. in Hottentot (Beach 1932). Although it has not given rise to tonal development, a similar synchronic correlation between consonant types and Fo has been found in other African languages (Hyman 1973 a.,b., Hyman and Schuh 1974). In Digo (Goldsmith 1990), a voiced initial assigns a low tone.

4.1.2. Phonetic explanations

Phonetic experiments (Lehiste and Peterson 1961, etc.) consistently show that "higher fundamental frequencies occur after a voiceless consonant and considerably lower fundamental frequencies occur after a voiced consonant (p.420).
(58).

	p	t	k	b	d	g
House & Fairbanks (1953)	127.9	127.1	127.2	120.9	120.6	122.8
Lehiste & Peterson (1961)	175	176	176	165	163	163
Mohr (1968)	130.7	129.8	131.1	125.1	124.1	125

The explanation to this phenomenon is given in two categories:

one to aerodynamic effects and the second to vocal cord tension (Hombert, p.81). Other explanations of vertical tension as the cause are given by Ohala (1972) and Evan & Krones (1974).

Gandour (1974) found in Thai languages that " a shorter part of the vowel was affected by the preceding consonant (about 30 msec for voiceless consonants and about 50 msec for voiced consonants)' and Hombert explains that "there may be a tendency in tone languages (which does not exist in non-tonal languages) to minimize the intrinsic effect of prevocalic consonants actively- probably in order to render the different tones maximally perceptually distinct" (Hombert1978). In the next section, we will discuss what effect initial consonants of Chinese has on tonal behaviors.

4.1.3. Initial consonants

Historically, Chinese initial consonants are divided among three groups: voiceless obstruents, voiced obstruents and sonorant consonants. In tonal merger and split caused by the voicing feature of the initial consonant, there is always a clear cut between voiceless obstruents and voiced obstruents. But for sonorant consonants they sometimes group with voiceless obstruents and sometimes with voiced obstruents in different varieties and at different stages of development.

From the previous section we know that an initial voiced obstruent has the effect of lowering the onset of a syllable. But is

the voiced obstruent the only group that can cause this effect? Goldsmith (1990) gives an account for the Depressor Tone Assignment, which means that a voiced obstruent at the onset position assigns a low tone, that "the specification 'C, +voice' is sufficient to restrict the rule to voiced consonants, on the assumption (which we take to be correct) that only the obstruents are marked in the lexicon for voicing; the sonorant and vowels, which are redundantly voiced, are lexically unspecified for voicing, and hence will not trigger (the low tone)" (p.34).

With Chinese, whether sonorant consonants take part in the tonal change is partly determined by whether they change the original tonal pattern or not.

An experiment is performed on American English (Hombert 1978) in which syllables with [p-], [b-] and [m-] initials are made and measured.
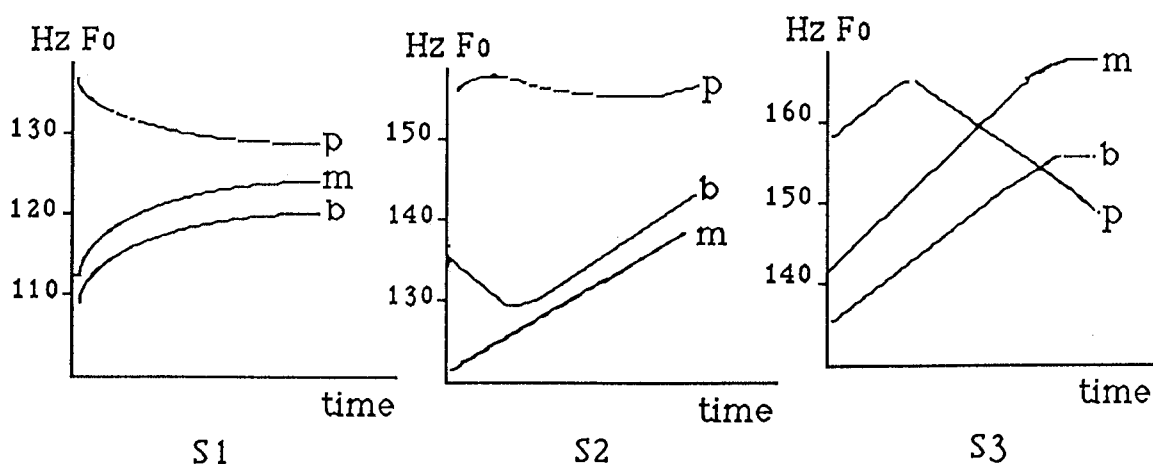
(59).

Figure: Average fundamental frequency values (in Hz) of vowels following English voiced and voiceless stops and sonorants from three individual speakers.

The behavior of [m-] is not consistent across subjects. It has a parallel but slightly higher track them [b-] in S1; it starts lower than [b-] in S2 and quickly catches up, while in S3 it starts higher than [b-] and travels higher. From the figure above, we see that [m-] has a wide pitch range. Sometimes it gets close to [p-] and sometimes it gets close to [b-]. This probably is the reason (or part of the reason) why sonorant initials are sometimes grouped with voiced obstruent initials and sometimes with voiceless obstruent initials in different tonal changes in Chinese.

The above figure also suggests that the behavior of different consonant initials is quite universal. In non-tone languages like English, [m-] functions the same as [b-], a voiced obstruent, in lowering the onset part of a syllable. The difference between [m-] and [b-] is that the pitch value of [m-] is not as low as that of [b-] in some cases. That may provide the explanation for the Tone I split: syllables with sonorant consonant as well as with voiced obstruents all become Tone 2 (rising) in modern Mandarin because they both have a lowered onset in the syllable, which has changed the tonal pattern of the original tone, thus making a level tone into a rising tone. In varieties where register distinction is preserved, syllables with a sonorant initial usually belong to the low register. We conclude that like voiced obstruents, sonorants can also lower the tone licensed by the syllable.

4.2. Tone II and III merger

According to Mei (1970a), Pulleyblank (1978), etc. the merger of Tone II and Tone III low register forms occurred around 800 A.D., probably shortly after tonogenesis, whereby Tone II low register became Tone III low register.

We have assumed that for tonal merger to happen, the merged tones should share a similar (if not identical) tonal pattern and syllable length. Both Tone II and III at this time were high rising with II short and III long. The major distinction between the two was the length. As for the low register, the voiced initial not only lowered the onset of the syllable, it also has the effect of lengthening it. L. Wang (1985) writes that Tone II and III share a similar tonal pattern at around 800 A.D. In Mei's version, at around 800 A.D. Tone II was short, high and rising; and Tone III was somewhat long, rising in contour and high in pitch (Mei 1970a). In Wu, syllables with both voiced obstruent and sonorant initials are low register syllables. In Wenzhou location Wu has eight tones and in Suzhou location it has seven tones in the four tonal categories in two registers with the low register of Tone II in Suzhou merged with the low register of Tone III. All the syllables with voiced obstruent initial and most of the syllables with sonorant initials took part in merger, though some syllables with sonorant initials have merged into other tones. So if they differed in some way, length might be that difference. We have not found any evidence to show that voiced initials can lengthen the syllable.

However, a voiced initial did lengthen Tone II low register syllables, then they would merge with the low register syllables of Tone III, which were already long. As for the high register, since the length distinction still existed so the two did not collapse. Moreover, the low register of Tone III might also be lengthened. But since Tone III was already long, the added length would not be phonologically significant and thus ignored.

For sonorant initials, however, the lengthening effect might not be that obvious, though they would still lower the onset of the syllable. Therefore, in some locations that have recognized this lengthening, the syllables with sonorant initials have merged with Tone III, as in Suzhou. In the majority locations however, syllables with sonorant initials do not lengthen the syllable as voiced obstruents do, and they are grouped with voiceless obstruent initial that did not merge just as in Mandarin.

4.3. Representation

The voiced initial's effect of lowering the F_0 of the following vowel is treated as Depressor Tone Assignment as the following by Goldsmith (1990):

(60).

DTA

$$\begin{bmatrix} \text{C} \\ +\text{voice} \end{bmatrix}$$
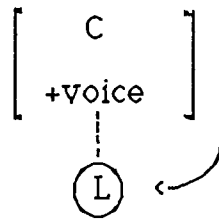
This illustrates how a rule of insertion is formulated in the notation of autosegmental phonology. Therefore in Digo every voiced obstruent will be associated with a low tone:

(61).

a n a b a b a d a r a

H   L   L   L   H

(p.35)

Although the rule can be applied to Chinese, we need some modifications. First of all, at the phonetic level, obstruents do not bear tones because tone-bearing units are defined as including sonorants only, so the above cannot be a surface representation form for Chinese.

From the previous discussion, a syllable in Chinese has two licensers that license two tones, which will be realized at the phonetic level, forming a lexical tone. As tones can only be associated with sonorants in both nucleus and coda, no tone can be associated with an onset obstruent. Besides, phonetically, the voiced obstruents only have the effect of lowering the pitch value

of the vowel that bears the pitch, so even underlyingly it would be ideal to suggest that C [+voice] in the onset assigns a low tone in the sense that this feature is licensed by the syllable that also licenses a tone. The feature is passed to the tone that is assigned an L feature by the licenser. Also, the syllable node as a licenser only licenses the tone realized over the nucleus vowel, therefore, it is necessary to treat the onset and nucleus vowel as a unit in tone licensing in this situation.

We assume that it works in the following way:
(62).

syllable {LR},{L}

onset   rhyme

nucleus   coda {H}

[+voice] C   V   N

L   H
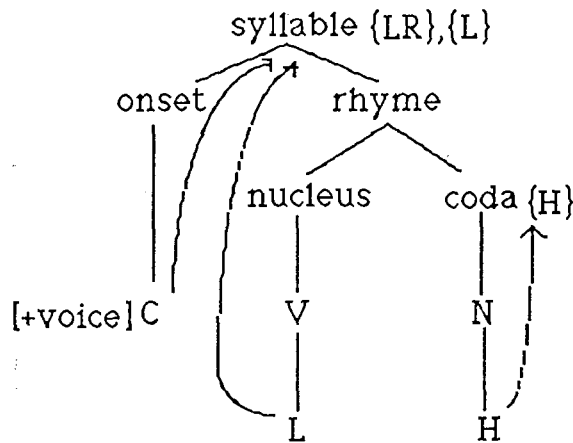
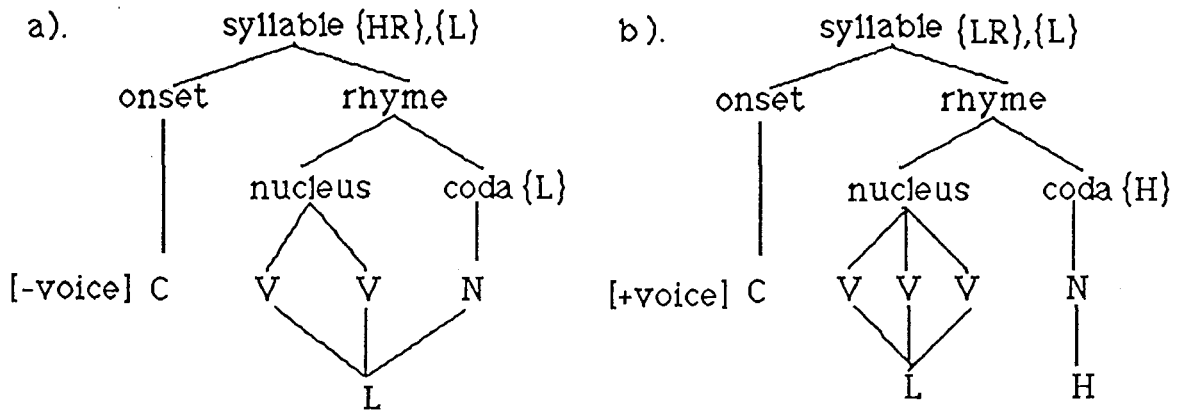First of all, the segmental feature [+voice] in the onset is licensed by the syllable node. As both nucleus and coda are filled with sonorants, by Association Convention they are associated with L and H respectively. The tonal feature L is licensed by the syllable that licenses a [+voice] feature as well.

The C [+voice] does not bear a tone physically. The Tone I high register has an L tone that is multi-associated with both the

nucleus and coda sonorant, giving a low, long and level tone. The length can be represented with a branching nucleus as is shown in (63) a):

(63).

a).
```
              syllable {HR},{L}              b).              syllable {LR},{L}
              /        \                                      /        \
          onset       rhyme                               onset       rhyme
            |         /    \                                 |        /    \
            |    nucleus   coda {L}                          |   nucleus   coda {H}
            |    /   \       |                               |  /  |  \      |
  [-voice] C    V    V       N                     [+voice] C  V   V   V     N
                \   /        |                                  \  |  /      |
                 \ /         N                                   \ | /       |
                  L                                               L          H
```

In (63) b) the Tone I low register, though the [+voice] in the onset also lengthens the nucleus vowel, the length is not phonologically significant. What matters is the new tonal pattern formed, from L to LH.
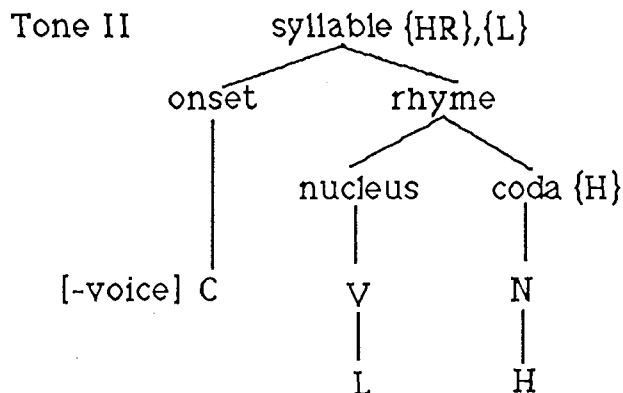
With Tone II and Tone III, as they are both rising tones, the lowering effect caused by the [+voice] feature of the onset is not that obvious compared with Tone I split. Phonetically, the lowering still happens. As the two licensed underlying tones are realized as a rising lexical tone already, the lowering effect is not phonologically significant in that no new tonal pattern is created.

But on the other hand, if it is as what we have predicted that the voiced obstruent initial will lengthen the duration of the syllable dramatically, the lengthening needs to be included in the
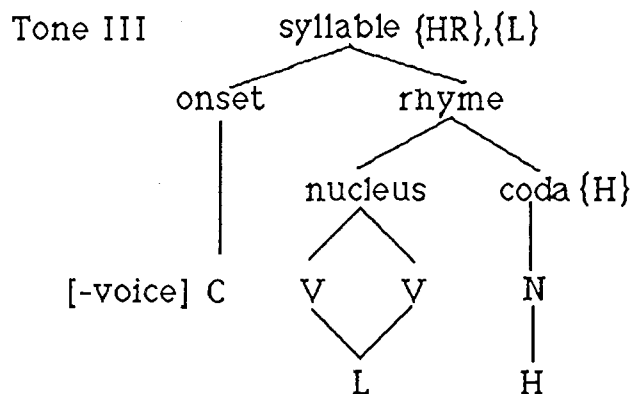
representation, for that is the part that makes the merger between the two tones possible.

Tone II and Tone III high registers have the following structures respectively:
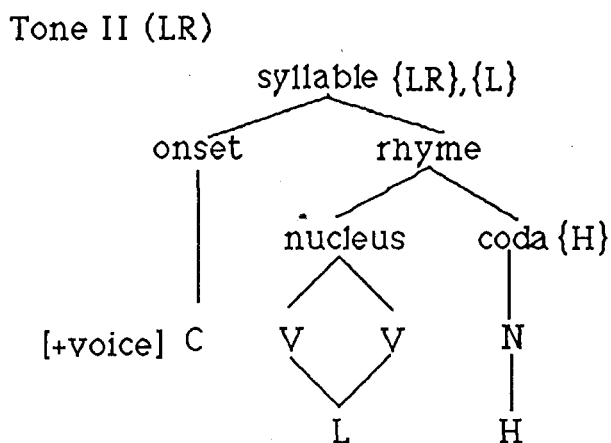
(64).

Tone II   syllable {HR},{L}

```
                          syllable {HR},{L}
                         /              \
                   onset                rhyme
                     |                 /      \
                     |            nucleus      coda {H}
                     |               |            |
         [-voice] C                  V            N
                                     |            |
                                     L            H
```

(65).

Tone III   syllable {HR},{L}

```
                        syllable {HR},{L}
                       /               \
                 onset                  rhyme
                   |                   /      \
                   |              nucleus      coda {H}
                   |              /     \         |
       [-voice] C               V       V        N
                                 \     /          |
                                  \   /           |
                                   L             H
```

Tone II is shorter than Tone III because Tone III has a branching nucleus. When the [+voice] feature in the onset is licensed by the syllable, which passes it to the nucleus vowel, it may cause the nucleus to branch. The low register of Tone II had the following Structure:

(66).

Tone II (LR)

```
                    syllable {LR},{L}
              onset              rhyme
                           nucleus      coda {H}
                              /\           |
  [+voice]  C       V        V        N
                        \  /                |
                          L                 H
```

which is similar to that of Tone III.

As both the [+voice] feature and the tones associated with the nucleus vowel are licensed by the same licenser, the syllable, both tones are assigned the feature L. The phonetic pattern of Tone II low register is thus the same as that of Tone III.

However, by the same process Tone III low register will also be lengthened. Since Tone III is already long, this lengthening is not phonologically significant. It will not bring about structural change. The fact is that the merger of the two low registers happened because they share a common tonal pattern and length.

4.4. Tone IV and its syllables

In Middle Chinese, Tone IV is the only category of the four that did not have a tonal pattern because of its voiceless stop ending. Instead of thinking that the language is "created" so, we would rather say that the loss of syllable final obstruent that in turn

gives way to tonal contrast is a long process that started early in history and is still going on. No tonal pattern can fully develop before the syllable drops its stop ending. But the situation with Tone IV is different from Tone II and its dropping of the glottal stop ending. For the latter, after the stop is dropped, a pitch pattern is turned into a tonal pattern, therefore a tone is "created". But with Tone IV, as there are tones existing in the language already at the time of the stop ending dropping, instead of creating a new tone, the syllables will merge into other tones according to the tonal patterns they have under the influence of both initial consonant and final consonant.

Tone IV in Modern Chinese is preserved to a different extent in different locations. Of the 17 varieties, 10 of them still have Tone IV category.

(67).

Locations	Stop Endings
Xiamen Guangzhou Meixian	[-p], [-t], [-k]
Nanchang	[-t], [-k]
Chaozhou	[-k],[-ʔ]
Fuzhou Suzhou Yangzhou Taiyuan (Wenzhou)	[-ʔ]

(*Dictionary of Chinese Dialects*

(in Chinese)1959)

-93-

In Wenzhou location, the glottal stop ending is dropped quite recently and the syllables have acquired a rising contour 23 in the high register and 12 in the low register. But they have not merged into any other tones yet. In all of the above varieties, this category is short and is usually represented by a digit, 5 for high register and 2 for low register in most cases.

If the stop does not drop until after it becomes a glottal stop, then upon dropping the tonal pattern initiated will be similar to that of Tone II at tonogenesis: a high, short and rising tone. One example would come from Wenzhou location where after the glottal stop is dropped, the syllable has acquired a rising pattern. Another example comes from the redistribution of Tone IV syllables. After it loses the stop ending, the syllable merged into tonal categories having rising patterns.

In most of the northern varieties including Mandarin, this process was completed before 1324 A.D. We assume that until then, Tone I low register, Tone II and Tone III were still rising in contour, because Tone IV syllables got merged into all three of them according to different types of initial consonants they have: syllables with voiced initials become Tone I low register; syllables with sonorant initial become Tone III and syllables with voiceless and zero initials become Tone II. Based on our previous argument, Tone IV category has acquired a rising contour after the stop ending is lost. The initial consonant, according to the lowering

ability of voiced obstruent and sonorant consonant, will give three different pitch height levels.

Before the final ending is deleted, the syllable does not have a tonal pattern as we have discussed in Chapter One. The syllable has only one tone realized, which shows a pitch height. At this stage, the pitch value of the tone associated with the nucleus vowel is determined by the voice feature of the onset. By licensing, the tone will obtain a higher pitch if the feature licensed is [-voice] . It will obtain a lower pitch if the feature [+voice] is licensed. After the stop ending in the coda is deleted, we have an empty coda which is refilled by vowel spreading. The feature [-voice] is licensed before C [-voice] deletes. After the stop is deleted, the feature is maintained and the tone licensed by the coda is assigned an H feature.

(68).
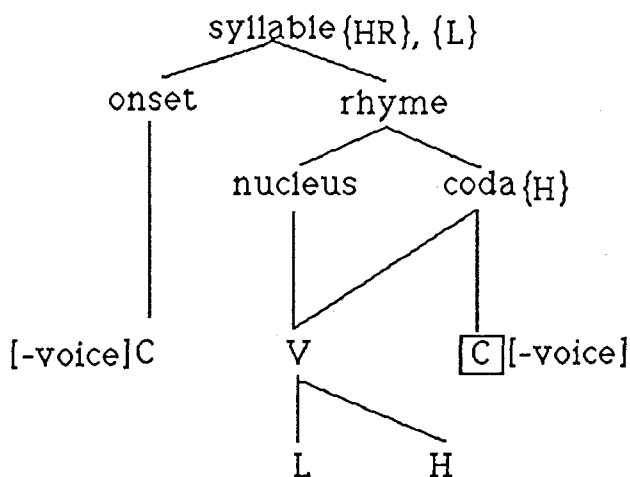
For syllables with a voiceless consonant initial, the structure is as the above. As is happened is tonogenesis, before the syllable loses its stop ending, the syllable is lengthened first. So the nucleus

vowel is multi-associated with both the nucleus and coda. As the [-voice] feature licensed by the coda will license an H tone associated with the coda sonorant (by vowel spreading), after the stop is dropped, the syllable will have an LH high rising pattern. (69).

syllable{HR},{L}
onset   rhyme
               nucleus   coda {H}
C   V   V   [C] [-voice]
[-voice]
               L   H
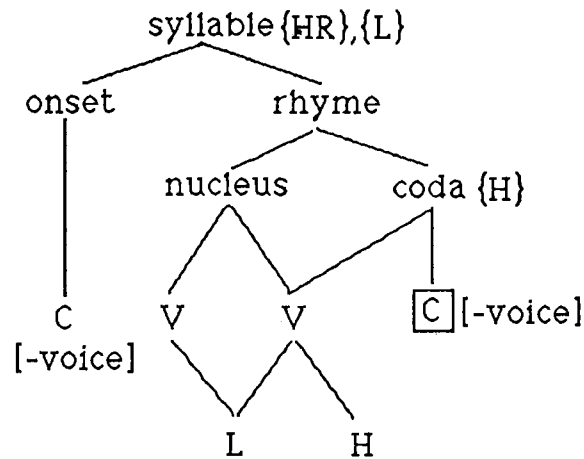
As the onset [+voice] feature also functions, it not only lowers the pitch of the tone licensed by the syllable, it also lengthens the vowel. That is why for syllables with a voiced obstruent initial, the syllable is long because of the [+voice] feature licensed by the syllable. The result is a long, low, rising tone. Hence, Tone IV syllables with voiceless initials have merged with Tone II that was still short, high and rising, and the syllables with voiced obstruents initials have merged with Tone I low register that was long, low and rising at the time of merging.

The last category concerns syllables with sonorant initials, which merged into Tone III. In Tone I split, syllables with sonorant initials grouped with syllables with voiced initials, that is, both [+voice] and [+son] features licensed by the syllable can assign

-96-

a L feature to the tone also licensed by the syllable. Though the lowering effect on the L tone differs between voiced obstruents and sonorants, it is enough to make the low register of a level tone change its tonal pattern from level to rising. But evidence from historical data, as well as from phonetic experiment both indicate that sonorant can not lower the pitch as low as a voiced obstruent does. For example, in Goldsmith's Depressor Tone Assignment (1990:35) sonorant onsets do not have the same function as voiced obstruents do in assigning a low tone. In the experiment performed by Hombert (1978) the F0 of a sonorant is usually between that of a voiced obstruent and a voiceless one. Thus we assume that compared with voiced obstruents, a sonorant initial does not lower the F0 of the tone, nor does it lengthen the vowel to the same extent as a voiced obstruent does. At the time when Tone IV loses its stop ending, the first three tones not only differ in pitch height, with Tone I lowest, Tone II highest and Tone III in between; also the length is different, too, with Tone I longest, Tone II shortest and Tone III in between. As far as the three types of initials are concerned, syllables with a voiced initial are longest and lowest, thus fit into Tone I low register. Syllables with voiceless initials are shortest and highest in pitch. So they merge with Tone II. Syllables with sonorant initials are in between, so they merge with Tone III.

4.5. Summary

We have looked at interaction between consonant and tone in terms of tonal split and merger. They can be easily explained in the autosegmental licensing theory. In Tone I split, the syllable that licenses a [+voice] or a [+sonorant] feature will assign an L feature to the tone associated with the nucleus vowel, thus making the two registers distinct in tonal patterns: level versus rising. For Tone II and III low register merger, the [+voice] licensed by the syllable not only lower the tone associated with the vowel but also length the vowel. When the two registers are close in tonal pattern and length, they merge into one. the lowering and lengthening effect of the initial consonant are arranged from the weakest to the strongest as voiceless obstruents, sonorants and voiced obstruents.

Conclusion

This thesis has demonstrated how the autosegmental licensing operates in Chinese. In autosegmental licensing, the syllable is seen as the domain of tone that includes both tone-bearing units like sonorants and non-tone-bearing units like obstruents. In a syllable, there are two licensers that function in their separate licensing domains. The syllable node as a primary licenser will license all the segmental features borne by the onset and the nucleus. It will also license the tonal features of the tone associated with the nucleus vowel. In this licensing domain, the syllable will assign a tonal feature to the tone it also licenses with reference to the licensed segmental feature. In the licensing domain of the coda, which is considered as a secondary licenser, the licenser will license both the segmental features of the coda and the tonal features of the tone associated with the coda sonorant. The syllable node is always a licenser that licenses the tone associated with the nucleus. But the coda is only a licenser of tone when the coda is filled with a sonorant that is associated with an underlying unit tone. If the coda fails to associate a tone, it will not license any tone. As the two licensers work in their separate domains, no segmental feature licensed by the syllable will affect the tone licensed by the coda. The same is true otherwise that no segmental features licensed by the coda will affect the tone licensed by the syllable. This explains why of the four tonal categories of Middle Chinese, only the first three

categories contrast in tonal patterns, while Tone IV syllables with the coda still filled with an obstruent did not develop its tonal pattern.

The process of tonogenesis can be represented in the autosegmental licensing. Before tonogenesis, the coda was filled with an obstruent that had blocked its association with an underlying unit tone. The obstruent ending was dropped upon tonogenesis, which made it possible for the coda to associate an underlying tone, either by the vowel spreading or by the reassociation of a nasal. Only when both licensers license underlying tones can a lexical tone be formed at the phonetic level. Hence, the segmental contrast gave way to the tonal contrast.

If only the tone licensed by the syllable is realized, the syllable will not have a lexical tone, instead, it can only carry a pitch which is determined by the segmental features licensed by the syllable.

The tonal changes like tonal split and merger can be represented in the autosegmental licensing, as well. The segmental features of the onset like [±voice] and [±son] will affect the pitch value of the tone licensed by the syllable. So syllables with a voiced obstruent onset or a sonorant onset will acquire a low register, and syllables with a voiceless obstruent or a zero onset will acquire a high register.
Those features not only determine the register features of the syllable, they also lengthen the nucleus vowel to a different extent

which in turn determines the condition for tonal mergers to happen.

The autosegmental licensing operates effectively in Chinese both synchronically and diachronically. It predicts a relationship between different syllable types and the tonal status of the syllables.

However, this thesis is the first attempt to account for the tonal development of Chinese in autosegmental licensing theory. More tonal phenomena from various languages need to be checked with the theory so that eventually this theory will operate effectively in all tone languages.

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